THREE ESSAYS IN DYNAMIC MACROECONOMICS

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Three Essays in Dynamic Macroeconomics

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DECLARATION OF ORIGINALITY

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- this thesis contains no material that has been submitted or accepted for a degree or diploma in any other educational institution;
- this is a true copy of the thesis approved by my advisor and thesis committee at Boğaziçi University, including final revisions required by them.

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ABSTRACT

Three Essays in Dynamic Macroeconomics

This thesis consists of three essays on dynamic macroeconomics. The first essay focuses on the relationship between government policy, education and wage inequality in a theoretical environment similar to the ones described in Acemoglu (1998, 2002). Analytical solution of the theoretical model indicates that the decentralized equilibrium of a two-sector economy where technological progress is fueled by invention of new technologies that are sold in a monopolistically competitive market is not socially optimal. The socially optimal government strategy involves the subsidization of the two sectors at the same rate as favoring one sector over the other subsidizing it at a higher rate distorts relative prices of intermediate goods substantially and hampers economic growth. The second article explores the relationship between the degree of central bank independence and inflation both empirically and theoretically. Empirical analysis shows a non-linear pattern between the two variables, and a game theoretical model taking place between the government and central bank is used to show that the potential informational asymmetry between the two player regarding the cost of fiscal expansion can successfully generate such a non-linear relationship. The third essay investigates the intergenerational educational mobility patterns in Europe using European Social Survey Dataset. The results of the econometric analysis show that educational mobility patterns show heterogeneity across countries, birth cohorts, genders and parent structure.

ÖZET

Dinamik Makroekonomi Üzerine Üç Makale

Bu tez dinamik makroekonomi ile ilgili üç makaleden oluşmaktadır. Birinci makalede devlet politikası, eğitim ve maaş eşitsizliği arasındaki ilişki Acemoglu (1998, 2002) tarafından kullanılan teorik modellere benzer bir çerçevede incelenmektedir. Teorik modelin analitik çözümü, iki sektörlü ve teknolojik ilerlemenin kar amacıyla icat edilen ve monopolistik rekabet içerisinde satılan yeni teknolojiler ile sağlandığı bir ekonominin desentralize dengesinin optimal olmadığını göstermektedir. Bu çerçevede izlenmesi gereken optimal devlet politikası, sektörlerden birinin görece daha fazla desteklenmesinin ekonomideki göreli fiyatların bozulması ve büyüme oranını düşürmesi nedenleriyle, varolan tüm sektörlerin aynı oranda teşvik edilmesini gerektirmektedir. İkinci makalede merkez bankası bağımsızlığı ve enflasyon arasındaki ilişki hem empirik hem de teorik çerçevede incelenmektedir. Empirik analiz sonunda bu iki makroekonomik değişken arasında doğrusal olmayan bir ilişkinin varlığı gözlenmektedir. Bu gözlemin teorik dinamiklerinin incelenmesi için oyuncularının merkez bankası ve devlet olduğu bir oyun teorisi modeli kurulmuş ve oyuncular arasında mali genişlemenin maaliyetine ilişkin bilgi asimetrisinin varlığının bu doğrusal olmayan ilişkiyi doğuracak unsurlardan biri olabilieceği gösterilmiştir. Üçüncü makalede European Social Survey veritabanından yararlanılarak Avrupa ülkelerindeki nesillerarası eğitimsel hareketlilik dinamikleri empiric olarak incelenmiştir. Ekonometrik analiz sonuçları eğitimsel hareketlilik trendlerinin ülke, nesil, cinsiyet ve aile yapısına göre farklılaştığını göstermiştir.

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DEDICATION

To my dear family (including my beloved cats), who provided me with endless love and gave me the strength to complete my PhD degree

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DIRECTED TECHNICAL CHANGE AND GOVERNMENT POLICY

1.1 Introduction

An interesting empirical observation about the relative wage trends in the United States from the beginnings of 1970's and onwards, that is a positive relationship between college premium (or relative wages of college graduates) and the relative supply of college graduates, led to the emergence of a new literature at the end of 1990's. This literature studies the underlying dynamics that dominate the negative substitution effect on the relative price of a factor in response to an increase in its relative supply. Studies such as Acemoglu (1998, 2002), Kiley (1999) and Galor and Moav (2000) present models that can account for this empirical observation either by having mechanisms that increase the productivity of a factor in response to an increase in its relative supply, or by having the demand for this factor increase more than the increase in its relative supply.

In this paper, I aim to explore whether changing the number of technologies available in each sector in favor of the high skill intensive sector, via taxes or subsidies, can result in an improvement of welfare compared to the undistorted decentralized equilibrium. If this is true, then governmental policies aimed to maximize welfare may be regarded as potential determinants of relative prices of production factors, aside from the relative supply of factors. To do this, I adopt the directed technical change models of Acemoglu (1998, 2002) in which the productivity of each production factor is determined endogenously by the number of technologies that complement each factor- which are created by innovators that operate according to their profit motives. The solution for the decentralized equilibrium of the model shows that such policies can affect the relative prices of factors, output and growth in this environment.

I am able to show that the equilibrium in the social planner environment and the decentralized economy are different from each other because of the monopolistically competitive nature of the technology markets and the pricing of technology varieties in the decentralized economy. Output and growth rate in the social planner environment are always different from the decentralized equilibrium. These results indicate that there is room for government intervention into the decentralized equilibrium of this economy where productivity of factors of production are determined endogenously.

After establishing those results, I aim to study the optimal policy of a government that wants to maximize welfare in this economy via distortionary or lump sum taxes/subsidies. The analytical solution of the social planner's problem implies that in order to increase output to its socially optimal levels, the government has to subsidize the price of all intermediate goods - that utilize labor with different skill levels - at the same rate. Hence, optimal government policy does not alter the skill premium (or relative price of labor with different skill levels) observed in the undistorted decentralized economy. Numerical simulations indicate that failing to subsidize each sector at the same rate results in a significant distortion of the relative prices of intermediate goods – which reduces profitability of inventing new technologies and therefore hampers economic growth.

1.2 The theoretical model

The model used in this paper is very similar (aside from income and intermediate good taxation) to the ones from Acemoglu (1998, 2002). The main difference in this study is the introduction of distortionary taxes and subsidies levied on the price of the intermediate good.

1.2.1 The decentralized economy

Total output, denoted with Y_t, is produced with a constant elasticity of substitution technology utilizing two intermediate goods, namely Y_{Ht} and Y_{Lt}, which are produced with skilled and unskilled labor, respectively.

$$Y_t = [\alpha Y_{Lt}^{\frac{\epsilon-1}{\epsilon}} + (1-\alpha) Y_{Ht}^{\frac{\epsilon-1}{\epsilon}}]^{\frac{\epsilon}{\epsilon-1}}$$

where ε denotes the elasticity of substitution between the skill intensive and non-skill intensive intermediate goods. The resource constraint of the representative agent in this economy is as follows:

$$C_t + M_t + R_t = Y_t$$

where C_t denotes consumption, M_t stands for machinery expenditure by intermediate good producers and R_t corresponds to the total research and development expenditure in period t. Each intermediate good is produced with the following technologies:

$$Y_{Ht} = \left(\int_0^{N_{Ht}} x_{Ht}(j)^{1-\beta} dj\right) H^{\beta}$$

$$Y_{Lt} = \left(\int_0^{N_{Lt}} x_{Lt}(j)^{1-\beta} dj \right) L^{\beta}$$

where $x_{Ht}(j)$ and $x_{Lt}(j)$ stand for the amount of machine variety j used in sectors H and L at time t, respectively. H and L correspond to skilled and unskilled labor supplies. N_{Ht} and N_{Lt} correspond to the total number of machine varieties in sector sectors H and L. Furthermore, $\beta \in [0,1]$. Producers in the unskilled labor-intensive intermediate good Y_L market face the following profit maximization problem:

$$\max_{\{x_{Lt}(j)\},L\}} (1+\tau_{Lt}) p_{Lt} Y_{Lt} - \int_0^{N_{Lt}} \chi_{Lt}(j) x_{Lt}(j) dj - \omega_{Lt} L$$

where τ_{Lt} corresponds to the amount of subsidies levied on good Y_L 's price, denoted with p_{Lt} . $\chi_{Lt}(j)$ stands for the rental price of machine j in sector L . ω_{Lt} is the rental price of factor L . Intermediate good producers in sector H also face the same profit maximization problem. The maximization problem of the intermediate good producers in sectors L and H yields the following:

$$x_{Lt}(j) = \left[\frac{(1-\beta)(1+\tau_{Lt}) p_{Lt}}{\chi_{Lt}(j)} \right]^{\frac{1}{\beta}} L$$

$$\omega_{Lt} = \beta(1+\tau_{Lt}) p_{Lt} \left[\int_0^{N_{Lt}} x_{Lt}(j)^{1-\beta} dj \right] L^{\beta-1}$$

$$x_{Ht}(j) = \left[\frac{(1-\beta)(1+\tau_{Ht}) p_{Ht}}{\chi_{Ht}(j)} \right]^{\frac{1}{\beta}} H$$

$$\omega_{Ht} = \beta(1+\tau_{Ht})\, p_{Ht} \left[\int_0^{N_{Ht}} x_{Ht}(j)^{1-\beta} dj \right] H^{\beta-1}$$

Moreover, the intermediate goods sector is competitive. Thus, the relative price of intermediate goods, denoted with p , is the ratio of the marginal productivities of each intermediate good:

$$p_t = \frac{p_{Ht}}{p_{Lt}} = \frac{MP_H}{MP_L} = \frac{\frac{\epsilon}{\epsilon-1}[\alpha Y_{Lt}^{\frac{\epsilon-1}{\epsilon}} + (1-\alpha) Y_{Ht}^{\frac{\epsilon-1}{\epsilon}}]^{\frac{1}{\epsilon-1}} \frac{\epsilon-1}{\epsilon}(1-\alpha) Y_{Ht}^{\frac{-1}{\epsilon}}}{\frac{\epsilon}{\epsilon-1}[\alpha Y_{Lt}^{\frac{\epsilon-1}{\epsilon}} + (1-\alpha) Y_{Ht}^{\frac{\epsilon-1}{\epsilon}}]^{\frac{1}{\epsilon-1}} \frac{\epsilon-1}{\epsilon}\alpha Y_{Lt}^{\frac{-1}{\epsilon}}}$$

$$p_t = \left(\frac{1-\alpha}{\alpha}\right)\left[\frac{Y_{Ht}}{Y_{Lt}}\right]^{\frac{-1}{\epsilon}}$$

After finding the expression describing the relative prices in terms of the ratio of the intermediate goods, the price of each intermediate good can be expressed in the following way:

$$p_{Lt} = \left[1 + \left(\frac{1-\alpha}{\alpha}\right)\left(\frac{Y_{Ht}}{Y_{Lt}}\right)^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{1}{\epsilon-1}} \alpha^{\frac{\epsilon}{\epsilon-1}}$$

$$p_{Ht} = \left[\left(\frac{1-\alpha}{\alpha}\right)^{-1}\left(\frac{Y_{Ht}}{Y_{Lt}}\right)^{\frac{1-\epsilon}{\epsilon}} + 1\right]^{\frac{1}{\epsilon-1}} (1-\alpha)^{\frac{\epsilon}{\epsilon-1}}$$

Technology monopolists both produce the machines used by intermediate good producers and invent new machine varieties. In sector L , each technology monopolist determines the rental price of his/her machines by solving the following profit maximization problem:

$$\max_{\chi_{Lt}(j)} \pi_{Lt} = [\chi_{Lt}(j) - \psi] x_{Lt}(j)$$

where ψ corresponds to the constant marginal cost of producing a machine. Profit maximization of a technology monopolist yields the following result:

$$\chi_{Lt}(j) = \frac{\psi}{1-\beta}$$

This result suggests that, since the technology market is not perfectly competitive but monopolistically competitive – that is the number of firms in this market is actually finite – instead of setting the rental price of a machine equal to its marginal cost of production, the technology monopolist instead charges a markup over this constant marginal cost since $1-\beta \in (0,1)$. Furthermore, since each technology is equally productive, the demand across different technologies in a specific sector is constant across all available technologies. Using the constancy of rental price of variety j across all varieties available in sector L (which is true for sector H as well) in the previously derived equations result in the following:

$$x_{Lt}(j) = \left[\frac{(1-\beta)^2 (1+\tau_{Lt}) p_{Lt}}{\psi} \right]^{\frac{1}{\beta}} L$$

$$x_{Ht}(j) = \left[\frac{(1-\beta)^2 (1+\tau_{Ht}) p_{Ht}}{\psi} \right]^{\frac{1}{\beta}} H$$

$$\omega_{Lt} = \beta \left[\frac{(1-\beta)^2}{\psi} \right]^{\frac{1}{\beta}-1} [(1+\tau_{Lt}) p_{Lt}]^{\frac{1}{\beta}} N_{Lt}$$

$$\omega_{Ht} = \beta \left[\frac{(1-\beta)^2}{\psi} \right]^{\frac{1}{\beta}-1} [(1+\tau_{Ht}) p_{Ht}]^{\frac{1}{\beta}} N_{Ht}$$

$$Y_{Lt} = \left[\frac{(1-\beta)^2 (1+\tau_{Lt}) p_{Lt}}{\psi} \right]^{\frac{1-\beta}{\beta}} N_{Lt} L$$

$$Y_{Ht} = \left[\frac{(1-\beta)^2 (1+\tau_{Ht}) p_{Ht}}{\psi} \right]^{\frac{1-\beta}{\beta}} N_{Ht} H$$

$$\pi_{Lt} = \left(\frac{\beta\psi}{1-\beta} \right) \left[\frac{(1-\beta)^2 (1+\tau_{Lt}) p_{Lt}}{\psi} \right]^{\frac{1}{\beta}} L$$

$$\pi_{Ht} = \left(\frac{\beta\psi}{1-\beta} \right) \left[\frac{(1-\beta)^2 (1+\tau_{Ht}) p_{Ht}}{\psi} \right]^{\frac{1}{\beta}} H$$

$$p_t = \left(\frac{\alpha}{1-\alpha} \right)^{-\frac{\beta\epsilon}{\sigma}} \gamma_t^{\frac{\beta\epsilon}{\sigma}-1} \left[\phi_t \frac{H}{L} \right]^{\frac{-\beta}{\sigma}}$$

where $\gamma_t \equiv \left(\frac{1+\tau_{Ht}}{1+\tau_{Lt}} \right)$, $\phi_t \equiv \frac{N_{Ht}}{N_{Lt}}$ and $\sigma \equiv \epsilon\beta + 1 - \beta$. As the demand for different varieties in each sector is equal, that is $x_{Lt}(j) = x_{Lt}(j') \ \ \forall j, j' \in [0, N_L]$ and $x_{Ht}(j) = x_{Ht}(j') \ \ \forall j, j' \in [0, N_H]$, the aggregate production function can be re-written in the following way in terms of output per technological variety/machinery in both sectors:

$$Y_t = \left\{ \alpha \underbrace{\left[N_{Lt}^{\beta+1} x_{Lt}^{1-\beta} \left(\frac{L}{N_{Lt}} \right)^{\beta} \right]^{\frac{\epsilon-1}{\epsilon}}}_{Y_{Lt} < Y_{Lt}^{*}} + (1-\alpha) \underbrace{\left[N_{Ht}^{\beta+1} x_{Ht}^{1-\beta} \left(\frac{H}{N_{Ht}} \right)^{\beta} \right]^{\frac{\epsilon-1}{\epsilon}}}_{Y_{Ht} < Y_{Ht}^{*}} \right\}^{\frac{\epsilon}{\epsilon-1}}$$

Holding the total amount of varieties, $N_t = \sum_{z \in \{L,H\}} N_{zt}$ and intermediate good prices constant, technological change in the form of an increase in N_{zt}, has two effects on production. First output per variety in sector Z (y_z) falls since skilled and unskilled labor supplies H and L are fixed and used in the same proportion (by z/N_{zt}) across all varieties in each sector. On the other hand, this technological change increases the productivity of investment in physical capital in this sector Z the following way- since there is decreasing returns to each physical capital variety, investing the same total amount in a setting where the number of physical capital types is higher yields a higher output, i.e. $N_z^{'} \left(x/N_{zt}^{'} \right)^{1-\beta} > N_z \left(x/N_{zt} \right)^{1-\beta}$ for $N_z^{'} > N_z$. When the two effects of increasing N_{zt} are combined while holding N_t and intermediate good prices constant, the investment productivity effect dominates the fall in the output per variety in sector Z, thus Y_{zt} tends to increase. However, when intermediate good prices are allowed to adjust, this increase in N_{zt} puts a downward pressure on Y_{zt} as the relative price of Z intensive intermediate good and demand for machinery in sector Z falls. The result for Y_{zt} in the end depends on those two opposing effects of technological change and model parameters in general.

Now turn to the technology monopolists' decision about choosing the sector in which he/she wants to innovate and create a new technology. Once a technology monopolist invents a new variety, he/she is able to obtain profits from selling this variety for an infinite amount of periods. Considering this, the technology monopolist decides in which sector he/she should make invention by comparing the discounted profits from inventing in sector L and H, denoted by V_{Lt} and V_{Ht} respectively.

$$V_{Lt} = \sum_{j=t+1}^{\infty} \frac{\pi_{Lj}}{\prod_{k=t}^{j}(1+r_k)}$$

$$V_{Ht} = \sum_{j=t+1}^{\infty} \frac{\pi_{Hj}}{\prod_{k=t}^{j}(1+r_k)}$$

where $(1+r_k)$ denotes the real interest rate at period k. Assuming that we are on a steady state where r, π_H, and π_L are constant over time, dividing the discounted profits earned from owning a technology in sector H to its sector L counterpart results in the steady state relative profitability of inventing a new technology across the two sectors:

$$\frac{V_{Ht}}{V_{Lt}} = \frac{\pi_{Ht}}{\pi_{Lt}} = \gamma^{1/\beta} p_t^{1/\beta} \frac{H}{L}$$

In each sector, the sector specific level of machine varieties available in each period depends on the current variety level and the amount of innovations made in the previous period.

$$N_{Lt+1} = N_{Lt} + \Delta N_{Lt}$$

$$N_{Ht+1} = N_{Ht} + \Delta N_{Ht}$$

where ΔN_{Lt} and ΔN_{Ht} correspond to the number of innovations made in sector L and sector H , which become available to use in period t . The functional forms governing the innovation process in each sectors are as follows:

$$\Delta N_{Lt} = \eta_L R_{Lt}$$

$$\Delta N_{Ht} = \eta_H R_{Ht}$$

The level of innovations made in each sector depends linearly on the research and development expenditure made in each sector, namely R_{Lt} and R_{Ht} . There is free-entry into innovation, i.e. research and development expenditure in each sector continues until the marginal cost and marginal benefit of making innovation are equal to each other. The following describe this condition:

$$1 = \eta_L V_{Lt}$$

$$1 = \eta_H V_{Ht}$$

Using the free entry conditions of the two sectors together results in the following:

$$\frac{V_{Ht}}{V_{Lt}} = \frac{\eta_L}{\eta_H}$$

This condition indicates that the relative profitability of making an innovation in a sector negatively depends on the ease of entry (or the productivity of research and development) of other competitors in this sector. After re-writing this relative profitability condition using the expressions for relative profits and prices, the following condition is obtained:

$$\frac{N_{Hss}^{de}}{N_{Lss}^{de}} \equiv \phi_{ss} = \gamma^{\epsilon} \left(\frac{1-\alpha}{\alpha} \right)^{\epsilon} \left(\frac{H}{L} \right)^{\sigma-1} \left(\frac{\eta_H}{\eta_L} \right)^{\sigma}$$

Since the steady state of the ratio of technologies available in each sector is expressed in terms of model parameters, the steady state values of other main variables can now be described in terms of model parameters as well:

$$p_{ss} = \gamma^{-1} \left(\frac{H}{L} \right)^{-\beta} \left(\frac{\eta_H}{\eta_L} \right)^{-\beta}$$

$$\frac{Y_{Hss}}{Y_{Lss}} = \left(\frac{1-\alpha}{\alpha} \right)^{\epsilon} \gamma^{\epsilon} \left(\frac{H}{L} \right)^{\epsilon\beta} \left(\frac{\eta_H}{\eta_L} \right)^{\epsilon\beta}$$

$$p_{Lss} = \left[1 + \left(\frac{1-\alpha}{\alpha} \right)^{\epsilon} \gamma^{(\epsilon-1)} \left(\frac{H}{L} \right)^{(\epsilon-1)\beta} \left(\frac{\eta_H}{\eta_L} \right)^{(\epsilon-1)\beta} \right]^{\frac{1}{\epsilon-1}} \alpha^{\frac{\epsilon}{\epsilon-1}}$$

$$p_{Hss} = \left[\left(\frac{1-\alpha}{\alpha} \right)^{-\epsilon} \gamma^{-(\epsilon-1)} \left(\frac{H}{L} \right)^{-(\epsilon-1)\beta} \left(\frac{\eta_H}{\eta_L} \right)^{-(\epsilon-1)\beta} + 1 \right]^{\frac{1}{\epsilon-1}} (1-\alpha)^{\frac{\epsilon}{\epsilon-1}}$$

$$\pi_{Lss} = \left(\frac{\beta\psi}{1-\beta} \right) \left[\frac{(1-\beta)^2 (1+\tau_{Lt}) \left[1 + \left(\frac{1-\alpha}{\alpha} \right)^{\epsilon} \gamma^{(\epsilon-1)} \left(\frac{H}{L} \right)^{(\epsilon-1)\beta} \left(\frac{\eta_H}{\eta_L} \right)^{(\epsilon-1)\beta} \right]^{\frac{1}{\epsilon-1}} \alpha^{\frac{\epsilon}{\epsilon-1}}}{\psi} \right]^{\frac{1}{\beta}} L$$

$$\pi_{Hss} = \left(\frac{\beta\psi}{1-\beta} \right) \left[\frac{(1-\beta)^2 (1+\tau_{Ht}) \left[\left(\frac{1-\alpha}{\alpha} \right)^{-\epsilon} \gamma^{-(\epsilon-1)} \left(\frac{H}{L} \right)^{-(\epsilon-1)\beta} \left(\frac{\eta_H}{\eta_L} \right)^{-(\epsilon-1)\beta} + 1 \right]^{\frac{1}{\epsilon-1}} (1-\alpha)^{\frac{\epsilon}{\epsilon-1}}}{\psi} \right]^{\frac{1}{\beta}} H$$

Furthermore, we can now write R_{Ht} in terms of R_{Lt} in the steady state:

$$R_{Hss} = \phi \frac{\eta_L}{\eta_H} R_{Lss}$$

The representative household in this economy is endowed with two factors H and L which are constant over time, and earns factor incomes from hiring those factors. Furthermore, the household receives a profit income in each period due to the ownership of technology monopolies and machine varieties. Household's factor income is taxed by τ. The household derives utility only from consumption, and makes research and development expenditure in each period. The maximization problem of the household is described by the following:

$$\max_{C_t, R_{Lt}, R_{Ht}} \sum_{t=0}^{\infty} \mu^t \ln(C_t)$$

$$\text{subject to } \sum_{t=0}^{\infty} \frac{(C_t + R_{Lt} + R_{Ht})}{\Pi_{k=0}^{t}(1+r_k)} = \sum_{t=0}^{\infty} \frac{(1-\tau)(\omega_{Lt} L + \omega_{Ht} H) + \Pi_t}{\Pi_{k=0}^{t}(1+r_k)}$$

$$\Pi_t = Y_t - (\omega_{Lt} L + \omega_{Ht} H)$$

$$C_t > 0$$

given N_{L0}

The government budget balance holds every period. Therefore:

$$\tau(\omega_{Lt} L + \omega_{Ht} H) = \tau_L Y_{Lt} p_{Lt} + \tau_H Y_{Ht} p_{Ht}$$

First order conditions of the consumer's problem are as follows:

$$C_t : \frac{\mu^t}{C_t} - \frac{\lambda}{(1+r)^t} = 0$$

$$C_{t+1} : \frac{\mu^{t+1}}{C_{t+1}} - \frac{\lambda}{(1+r)^{t+1}} = 0$$

Combining those two first order conditions give us the intertemporal Euler equation for consumption:

$$g_C = \frac{C_{t+1}}{C_t} = \mu(1+r)$$

where interest rate r can be obtained from the free entry condition of technology monopolist's problem in the following way:

$$1 = \eta_L \sum_{j=t+1}^{\infty} \frac{\pi_{Lj}}{\Pi_{k=t+1}^{j}(1+r_k)}$$

$$1 = \eta_L \pi_L \sum_{j=t+1}^{\infty} \frac{1}{(1+r)^{j-t}}$$

$$1 = \eta_L \pi_L \frac{1}{r}$$

$$r = \eta_L \pi_L$$

Thus, the growth rate of consumption at the steady state where ϕ is constant is the following

$$g_C = \mu(1+\eta_L \pi_L) = \mu(1+\eta_H \pi_H)$$

As factor incomes, ω_L and ω_H , and total profit income from inventing and selling new machinery/technology are linear in N_{Lt} , consumption and machine varieties grow at the same rate in the steady state of ϕ. Thus, we can write consumption and machine varieties in each period in terms of their growth rates and initial values

$$C_t = C_0 {g_C}^t$$

$$N_{Lt} = N_{L0} {g_C}^t$$

where $N_{L0} = N_0 / 1+\phi$.

The decentralized equilibrium in this setting is possibly not optimal because of two reasons. First, each variety is produced and sold monopolistically, thus compared to the case where the technology market is competitive rental price of each machine will be higher and there will be less demand for each technology variety in the decentralized equilibrium. Furthermore, the growth rate of the economy will depend on the profitability of inventing new varieties of technology-which is also potentially lower than the optimal level because of the suboptimal levels of technology variety demand.

1.2.2 The social planner's problem

In order to identify the sources of inefficiency in the decentralized equilibrium, now consider the following social planner's problem. In the case of the social planner, contrary to the decentralized equilibrium, there will not be separate firms for final and intermediate good production, machinery production and technology invention. Instead, the social planner will perform those separate production activities together. In this case, the optimization problem will be the following:

$$\max_{C_t, R_{Lt}, R_{Ht}} \sum_{t=0}^{\infty} \mu^t \ln(\mathrm{C}_t) \text{ subject to } C_t + R_{Lt} + R_{Ht} = Y_t - \psi \left[\int_0^{N_{Lt}} x_{Lt}(j)dj + \int_0^{N_{Ht}} x_{Ht}(j)dj \right]$$

$$Y_t = [\alpha Y_{Lt}^{\frac{\epsilon-1}{\epsilon}} + (1-\alpha) Y_{Ht}^{\frac{\epsilon-1}{\epsilon}}]^{\frac{\epsilon}{\epsilon-1}}$$

$$Y_{Ht} = \left(\int_0^{N_{Ht}} x_{Ht}(j)^{1-\beta} dj \right) H^{\beta}$$

$$Y_{Lt} = \left(\int_0^{N_{Lt}} x_{Lt}(j)^{1-\beta} dj \right) L^{\beta}$$

$$N_{Ht+1} = N_{Ht} + \eta_H R_{Ht}$$

$$N_{Lt+1} = N_{Lt} + \eta_L R_{Lt}$$

$$C_t > 0$$

$$\text{given } N_{L0}, N_{H0}$$

The social planner's problem is different from the one presented in the decentralized economy in the following regards: New technologies are not produced monopolistically, and one agent conducts all production stages. The only cost of production arises due to machines used in production, i.e. ψ . First order conditions of the social planner's problem with respect to $x_{Lt}(j)$ and $x_{Ht}(j)$ are as follows:

$$[\alpha Y_{Lt}^{\frac{\epsilon-1}{\epsilon}} + (1-\alpha)Y_{Ht}^{\frac{\epsilon-1}{\epsilon}}]^{\frac{1}{\epsilon-1}}(1-\beta)\alpha Y_{Lt}^{\frac{-1}{\epsilon}} x_{Lt}(j)^{-\beta} L^{\beta} - \psi = 0$$

$$[\alpha Y_{Lt}^{\frac{\epsilon-1}{\epsilon}} + (1-\alpha)Y_{Ht}^{\frac{\epsilon-1}{\epsilon}}]^{\frac{1}{\epsilon-1}}(1-\beta)(1-\alpha)Y_{Ht}^{\frac{-1}{\epsilon}} x_{Ht}(j)^{-\beta} H^{\beta} - \psi = 0$$

These first order conditions simply suggest that the demand for each type of machinery will be such that at the socially optimal case the marginal product of a specific type of machinery will be equal to its constant marginal cost of production ψ . Rearranging the first order conditions gives the optimal machinery demands for the social planner's case:

$$x_{Lt}^{sp}(j) = \left(\frac{\psi}{1-\beta}\right)^{-\frac{1}{\beta}} \alpha^{\frac{\epsilon}{\sigma-1}} L \left[1 + \left(\frac{1-\alpha}{\alpha}\right)\left(\frac{Y_{Ht}}{Y_{Lt}}\right)^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{1}{\sigma-1}}$$

$$x_{Ht}^{sp}(j) = \left(\frac{\psi}{1-\beta}\right)^{-\frac{1}{\beta}} (1-\alpha)^{\frac{\varepsilon}{\sigma-1}} H \left[1 + \left(\frac{1-\alpha}{\alpha}\right)^{-1}\left(\frac{Y_{Ht}}{Y_{Lt}}\right)^{\frac{-(\epsilon-1)}{\epsilon}}\right]^{\frac{1}{\sigma-1}}$$

$$= \left(\frac{\psi}{1-\beta}\right)^{-\frac{1}{\beta}} (1-\alpha)^{\frac{\varepsilon}{\sigma-1}} H \left[\frac{1 + \left(\frac{1-\alpha}{\alpha}\right)\left(\frac{Y_{Ht}}{Y_{Lt}}\right)^{\frac{\varepsilon-1}{\varepsilon}}}{\left(\frac{1-\alpha}{\alpha}\right)\left(\frac{Y_{Ht}}{Y_{Lt}}\right)^{\frac{\varepsilon-1}{\varepsilon}}}\right]^{\frac{1}{\sigma-1}}$$

According to these results, demand across different technology varieties is again constant, i.e. $x_{zt}(j) = x_{zt}(j^{'}) \ \forall i, i^{'} \in [0, N_{Zt}]$ for $z \in \{H, L\}$. Combining the variety demands in each sector gives:

$$\frac{x_{Ht}}{x_{Lt}} = \left(\frac{1-\alpha}{\alpha}\right)^{\frac{\varepsilon}{\sigma-1}} \left(\frac{H}{L}\right) \left(\frac{1-\alpha}{\alpha}\right)^{\frac{-1}{\sigma-1}} \left(\frac{Y_{Ht}}{Y_{Lt}}\right)^{\frac{-1(\varepsilon-1)}{(\sigma-1)\varepsilon}} = \left(\frac{1-\alpha}{\alpha}\right)^{\frac{1}{\beta}} \left(\frac{Y_{Ht}}{Y_{Lt}}\right)^{\frac{-1}{\varepsilon\beta}} \left(\frac{H}{L}\right)$$

$$\frac{Y_{Ht}}{Y_{Lt}} = \frac{N_{Ht} x_{Ht}^{1-\beta} H^{\beta}}{N_{Lt} x_{Lt}^{1-\beta} L^{\beta}} = \left(\frac{1-\alpha}{\alpha}\right)^{\frac{\epsilon(1-\beta)}{\sigma}} \left(\frac{N_{Ht}}{N_{Lt}}\right)^{\frac{\epsilon\beta}{\sigma}} \left(\frac{H}{L}\right)^{\frac{\epsilon\beta}{\sigma}}$$

$$x_{Lt}^{sp} = \left(\frac{\psi}{1-\beta}\right)^{-\frac{1}{\beta}} L\alpha^{\frac{\epsilon}{\sigma}} \left\{1 + \left(\frac{1-\alpha}{\alpha}\right)^{\frac{\epsilon}{\sigma}} \left(\frac{N_{Ht}}{N_{Lt}}\right)^{\frac{\sigma-1}{\sigma}} \left(\frac{H}{L}\right)^{\frac{\sigma-1}{\sigma}}\right\}^{\frac{1}{\sigma-1}}$$

$$x_{Lt}^{de} = \left(\frac{\psi}{(1-\beta)^2}\right)^{-\frac{1}{\beta}} L\alpha^{\frac{\epsilon}{\sigma}} \left\{1 + \left(\frac{1-\alpha}{\alpha}\right)^{\frac{\epsilon}{\sigma}} \left(\frac{N_{Ht}}{N_{Lt}}\right)^{\frac{\sigma-1}{\sigma}} \left(\frac{H}{L}\right)^{\frac{\sigma-1}{\sigma}}\right\}^{\frac{1}{\sigma-1}}$$

The solution of the social planner's problem and its comparison with the decentralized equilibrium yields two important observations. First, holding the number of technology varieties for each sector constant across the two environments the demand for machinery/physical capital will be higher in the social planner's environment compared to the decentralized economy (that is $x_{Lt}^{sp} > x_{Lt}^{de}$) since $\beta \in [0,1]$.

Now we must investigate whether the ratio of the number of technologies available in each sector (which affects the levels of intermediate good prices, productivity of labor with different skill levels, machinery demand and growth) is different in the social planner's setting compared to the decentralized economy. Using the results we have obtained so far, we can obtain the following expression describing the relative demand for machinery across the two sectors in terms of the number of technologies available in each sector:

$$\frac{x_{Ht+1}}{x_{Lt+1}} = \left(\frac{1-\alpha}{\alpha}\right)^{\frac{\varepsilon}{\sigma}} \left(\frac{N_{Ht+1}}{N_{Lt+1}}\right)^{\frac{-1}{\sigma}} \left(\frac{H}{L}\right)^{\frac{\sigma-1}{\sigma}}$$

Furthermore, using the expression for the socially optimal level of demand for a specific variety in sector L, the following can also be obtained:

$$\frac{\partial x_L}{\partial N_H} = -\left(\frac{N_L}{N_H}\right)\frac{\partial x_L}{\partial N_L}$$

The first order conditions of the social planner's problem with respect to the number of technologies available in each sector can be described as:

$$-\frac{\lambda_t}{\eta_L} + \lambda_{t+1}\left[\frac{1}{\eta_L} + \frac{\partial Y_{t+1}}{\partial N_{Lt+1}} - \psi\left(x_{Lt+1} + N_{Lt+1}\frac{\partial x_{Lt+1}}{\partial N_{Lt+1}} + N_{Ht+1}\frac{\partial x_{Ht+1}}{\partial N_{Lt+1}}\right)\right] = 0$$

Re-arranging the first order condition results in:

$$\frac{\lambda_t}{\lambda_{t+1}} = 1 + \eta_L\frac{\partial Y_{t+1}}{\partial N_{Lt+1}} - \eta_L\psi\left(x_{Lt+1} + N_{Lt+1}\frac{\partial x_{Lt+1}}{\partial N_{Lt+1}} + N_{Ht+1}\frac{\partial x_{Ht+1}}{\partial N_{Lt+1}}\right)$$

We know that

$$\frac{\partial Y_L}{\partial N_L} = x_L^{1-\beta} L^{\beta} + (1-\beta) N_L x_L^{-\beta} L^{\beta} \left(\frac{\partial x_L}{\partial N_L} \right)$$

Define $K \equiv \left(\frac{1-\alpha}{\alpha} \right)^{\frac{\epsilon}{\sigma}} \left(\frac{N_{Ht}}{N_{Lt}} \right)^{\frac{\sigma-1}{\sigma}} \left(\frac{H}{L} \right)^{\frac{\sigma-1}{\sigma}}$. Therefore:

$$\frac{x_{Ht+1}}{x_{Lt+1}} = K \left(\frac{N_{Lt+1}}{N_{Ht+1}} \right)$$

$$Y = \left[1+K\right]^{\frac{\varepsilon}{\varepsilon-1}} \alpha^{\frac{\varepsilon}{\varepsilon-1}} Y_L$$

$$\frac{\partial Y}{\partial N_L} = \frac{\varepsilon}{\varepsilon-1} \left[1+K\right]^{\frac{1}{\varepsilon-1}} \frac{K}{N_L} \left(\frac{1-\sigma}{\sigma} \right) \alpha^{\frac{\varepsilon}{\varepsilon-1}} Y_L + \left[1+K\right]^{\frac{\varepsilon}{\varepsilon-1}} \alpha^{\frac{\varepsilon}{\varepsilon-1}} \frac{\partial Y_L}{\partial N_L}$$

$$\frac{\partial Y}{\partial N_L} = \left[1+K\right]^{\frac{1}{\varepsilon-1}} K \left[\frac{(1-\sigma)\varepsilon}{\sigma(\varepsilon-1)} \right] \alpha^{\frac{\varepsilon}{\varepsilon-1}} x_L^{1-\beta} L^{\beta} + \left[1+K\right]^{\frac{\varepsilon}{\varepsilon-1}} \alpha^{\frac{\varepsilon}{\varepsilon-1}} x_L^{-\beta} L^{\beta} \left\{ x_L + (1-\beta) N_L \left(\frac{\partial x_L}{\partial N_L} \right) \right\}$$

Then the demand for a variety in sector L and its derivative with respect to the number of available varieties in this sector can now be written as:

$$x_{Lt} = \left(\frac{\psi}{(1-\beta)} \right)^{-\frac{1}{\beta}} L \alpha^{\frac{\epsilon}{\sigma}} \left\{1+K\right\}^{\frac{1}{\sigma-1}}$$

$$\frac{\partial x_L}{\partial N_L} = \left(\frac{\psi}{(1-\beta)} \right)^{-\frac{1}{\beta}} L \alpha^{\frac{\epsilon}{\sigma}} \left\{1+K\right\}^{\frac{1}{\sigma-1}-1} \left(-\frac{1}{\sigma} \right) \frac{K}{N_L} = x_L \left(-\frac{1}{\sigma} \right) \frac{K}{(1+\mathrm{K}) N_L}$$

Using this information, the derivative of total output with respect to the number of technologies available in sector L can be obtained as:

$$\frac{\partial Y}{\partial N_L} = \left[1+K\right]^{\frac{\varepsilon}{\varepsilon-1}} \alpha^{\frac{\varepsilon}{\varepsilon-1}} x_L^{1-\beta} L^{\beta} \left\{1 - \frac{(1-\beta)\,\mathrm{K}}{\sigma\left(1+K\right)}\right\}$$

Now calculate the term $x_{Lt+1} + N_{Lt+1}\frac{\partial x_{Lt+1}}{\partial N_{Lt+1}} + N_{Ht+1}\frac{\partial x_{Ht+1}}{\partial N_{Lt+1}}$ in terms of model parameters:

$$\begin{aligned} x_{Lt+1} + N_{Lt+1}\frac{\partial x_{Lt+1}}{\partial N_{Lt+1}} + N_{Ht+1}\frac{\partial x_{Ht+1}}{\partial N_{Lt+1}} &= x_{Lt+1} + N_{Lt+1}\frac{\partial x_{Lt+1}}{\partial N_{Lt+1}} + N_{Ht+1}\left(\frac{N_{Lt+1}}{N_{Ht+1}}\right)K\left\{\left(\frac{1}{\sigma}\right)\frac{x_{Lt+1}}{N_{Lt+1}} + \frac{\partial x_{Lt+1}}{\partial N_{Lt+1}}\right\} \\ &= x_{Lt+1} + x_{Lt+1}\left(-\frac{1}{\sigma}\right)\frac{K}{(1+\mathrm{K})} + \left(\frac{K}{\sigma}\right)x_{Lt+1} + Kx_{Lt+1}\left(-\frac{1}{\sigma}\right)\frac{K}{(1+\mathrm{K})} = x_{Lt+1} + x_{Lt+1}\left(-\frac{1}{\sigma}\right)K + \left(\frac{K}{\sigma}\right)x_{Lt+1} \\ &= x_{Lt+1} \end{aligned}$$

Thus, the intertemporal Euler equation can finally be written as:

$$\frac{\lambda_t}{\lambda_{t+1}} = 1 + \eta_L\left[1+K\right]^{\frac{1}{\varepsilon-1}} K\left[\frac{\left(1-\sigma\right)\varepsilon}{\sigma\left(\varepsilon-1\right)}\right]\alpha^{\frac{\varepsilon}{\varepsilon-1}} x_{Lt+1}^{1-\beta}L^{\beta} + \eta_L\left[1+K\right]^{\frac{\varepsilon}{\varepsilon-1}}\alpha^{\frac{\varepsilon}{\varepsilon-1}} x_{Lt+1}^{1-\beta}L^{\beta}\left\{1 - \frac{(1-\beta)\,\mathrm{K}}{\sigma(1+\mathrm{K})}\right\} - \eta_L\psi x_{Lt+1}$$

The intertemporal Euler equation with respect to the number of technologies available in sector H can be expressed with the following:

$$-\frac{\lambda_t}{\eta_H} + \lambda_{t+1}\left[\frac{1}{\eta_H} + \frac{\partial Y_{t+1}}{\partial N_{Ht+1}} - \psi\left(x_{Ht+1} + N_{Ht+1}\frac{\partial x_{Ht+1}}{\partial N_{Ht+1}} + N_{Lt+1}\frac{\partial x_{Lt+1}}{\partial N_{Ht+1}}\right)\right] = 0$$

Re-arranging this condition results in:

$$\frac{\lambda_t}{\lambda_{t+1}} = 1 + \eta_H\frac{\partial Y_{t+1}}{\partial N_{Ht+1}} - \eta_H\psi\left(x_{Ht+1} + N_{Ht+1}\frac{\partial x_{Ht+1}}{\partial N_{Ht+1}} + N_{Lt+1}\frac{\partial x_{Lt+1}}{\partial N_{Ht+1}}\right)$$

From the analysis so far, we have the following information:

$$Y = \left[\frac{1+K}{K}\right]^{\frac{\varepsilon}{\varepsilon-1}} (1-\alpha)^{\frac{\varepsilon}{\varepsilon-1}} Y_H$$

$$\frac{\partial Y}{\partial N_L} = \frac{\varepsilon}{\varepsilon-1}\left[\frac{1+K}{K}\right]^{\frac{1}{\varepsilon-1}} \frac{1}{KN_H}\left(\frac{1-\sigma}{\sigma}\right)(1-\alpha)^{\frac{\varepsilon}{\varepsilon-1}} Y_H + \left[\frac{1+K}{K}\right]^{\frac{\varepsilon}{\varepsilon-1}} (1-\alpha)^{\frac{\varepsilon}{\varepsilon-1}} \frac{\partial Y_H}{\partial N_H}$$

$$\frac{\partial Y_H}{\partial N_H} = x_H^{1-\beta} H^{\beta} + (1-\beta) N_H x_H^{-\beta} H^{\beta}\left(\frac{\partial x_H}{\partial N_H}\right)$$

The demand for a variety in sector H and its derivative with respect to the number of available varieties in this sector can now be written as:

$$x_{Ht} = \left(\frac{\psi}{(1-\beta)}\right)^{-\frac{1}{\beta}} H(1-\alpha)^{\frac{\epsilon}{\sigma}} \left\{\frac{1+K}{K}\right\}^{\frac{1}{\sigma-1}}$$

$$\frac{\partial x_H}{\partial N_H} = x_H\left(\frac{-1}{\sigma}\right)\frac{1}{(1+\mathrm{K})\,\mathrm{N}_H}$$

$$\frac{\partial x_H}{\partial N_L} = \frac{\partial x_H}{\partial N_L}\left(-\frac{N_H}{N_L}\right)$$

Merging all expressions together yields:

$$\frac{\partial Y}{\partial N_H} = \left[1+\left(\frac{1}{K}\right)\right]^{\frac{\varepsilon}{\varepsilon-1}} (1-\alpha)^{\frac{\varepsilon}{\varepsilon-1}} \left\{x_H^{1-\beta} H^{\beta} + (1-\beta) N_H x_H^{-\beta} H^{\beta}\left[x_H\left(\frac{-1}{\sigma}\right)\frac{1}{(1+\mathrm{K})\,\mathrm{N}_H}\right]\right\}$$

$$\frac{\partial Y}{\partial N_H} = \left[\frac{1+K}{K}\right]^{\frac{1}{\varepsilon-1}} \frac{1}{K}\left[\frac{(1-\sigma)\varepsilon}{\sigma(\varepsilon-1)}\right](1-\alpha)^{\frac{\varepsilon}{\varepsilon-1}} x_H^{1-\beta} H^{\beta} + \left[\frac{1+K}{K}\right]^{\frac{\varepsilon}{\varepsilon-1}} (1-\alpha)^{\frac{\varepsilon}{\varepsilon-1}} x_H^{1-\beta} H^{\beta}\left\{1-\left(\frac{1-\beta}{\sigma}\right)\frac{1}{(1+\mathrm{K})}\right\}$$

Now calculate the term $x_{Ht+1} + N_{Ht+1}\dfrac{\partial x_{Ht+1}}{\partial N_{Ht+1}} + N_{Lt+1}\dfrac{\partial x_{Lt+1}}{\partial N_{Ht+1}}$ in terms of model parameters:

$$x_{Ht+1} + N_{Ht+1}\frac{\partial x_{Ht+1}}{\partial N_{Ht+1}} + N_{Lt+1}\frac{\partial x_{Lt+1}}{\partial N_{Ht+1}} = x_{Ht+1} + N_{Ht+1}\frac{\partial x_{Ht+1}}{\partial N_{Ht+1}} + N_{Lt+1}\left(\frac{1}{KN_{Lt+1}}\right)\left[N_{Ht+1}\frac{\partial x_{Ht+1}}{\partial N_{Ht+1}} + \frac{x_{Ht+1}}{\sigma}\right]$$

$$= x_{Ht+1} + N_{Ht+1}\left(x_{Ht+1}\left(\frac{-1}{\sigma}\right)\frac{1}{(1+\mathrm{K})\,\mathrm{N}_{Ht+1}}\right) + N_{Lt+1}\left(\frac{1}{KN_{Lt+1}}\right)\left[N_{Ht+1}\left(x_H\left(\frac{-1}{\sigma}\right)\frac{1}{(1+\mathrm{K})\,\mathrm{N}_{Ht+1}}\right) + \frac{x_{Ht+1}}{\sigma}\right]$$

$$= x_{Ht+1} - \frac{x_{Ht+1}}{\sigma(1+K)} + \frac{1}{K}\left[\frac{-x_{Ht+1}}{\sigma(1+\mathrm{K})} + \frac{x_{Ht+1}}{\sigma}\right] = x_{Ht+1} - \frac{Kx_{Ht+1}}{\sigma K(1+K)} + \frac{-x_{Ht+1}}{\sigma K(1+\mathrm{K})} + \frac{x_{Ht+1}}{K\sigma} = x_{Ht+1}$$

Thus, the intertemporal Euler equation with respect to the number of technologies available in sector H can finally be written as:

$$\frac{\lambda_t}{\lambda_{t+1}} = 1 + \eta_H\left[\frac{1+K}{K}\right]^{\frac{1}{\varepsilon-1}}\frac{1}{K}\left[\frac{(1-\sigma)\varepsilon}{\sigma(\varepsilon-1)}\right](1-\alpha)^{\frac{\varepsilon}{\varepsilon-1}}x_{Ht+1}^{1-\beta}H^{\beta}$$
$$+\eta_H\left[\frac{1+K}{K}\right]^{\frac{\varepsilon}{\varepsilon-1}}(1-\alpha)^{\frac{\varepsilon}{\varepsilon-1}}x_{Ht+1}^{1-\beta}H^{\beta}\left\{1-\frac{(1-\beta)}{\sigma(1+\mathrm{K})}\right\} - \eta_H\psi x_{Ht+1}$$

Combining the two intertemporal Euler equations from sectors H and L give the no-arbitrage condition with respect to the number of available technologies across sectors:

$$\eta_L\left[1+K\right]^{\frac{1}{\varepsilon-1}}K\left[\frac{(1-\sigma)\varepsilon}{\sigma(\varepsilon-1)}\right]\alpha^{\frac{\varepsilon}{\varepsilon-1}}x_{Lt+1}^{1-\beta}L^{\beta}+\eta_L\left[1+K\right]^{\frac{\varepsilon}{\varepsilon-1}}\alpha^{\frac{\varepsilon}{\varepsilon-1}}x_{Lt+1}^{1-\beta}L^{\beta}\left\{1-\frac{(1-\beta)\mathrm{K}}{\sigma(1+\mathrm{K})}\right\}-\eta_L\psi x_{Lt+1}$$

$$=\eta_H\left[\frac{1+K}{K}\right]^{\frac{1}{\varepsilon-1}}\frac{1}{K}\left[\frac{(1-\sigma)\varepsilon}{\sigma(\varepsilon-1)}\right](1-\alpha)^{\frac{\varepsilon}{\varepsilon-1}}x_{Ht+1}^{1-\beta}H^{\beta}$$

$$+\eta_H\left[\frac{1+K}{K}\right]^{\frac{\varepsilon}{\varepsilon-1}}(1-\alpha)^{\frac{\varepsilon}{\varepsilon-1}}x_{Ht+1}^{1-\beta}H^{\beta}\left\{1-\frac{(1-\beta)}{\sigma(1+\mathrm{K})}\right\}-\eta_H\psi x_{Ht+1}$$

Now in order to write the expression above linearly in terms of machinery demands, write the terms $x_{Lt+1}^{-\beta}L^{\beta}$ and $x_{Ht+1}^{-\beta}H^{\beta}$ in detail:

$$x_{Lt}^{-\beta}L^{\beta}=\left(\frac{\psi}{1-\beta}\right)\alpha^{\frac{-\varepsilon\beta}{\sigma-1}}L^{-\beta}\left[1+K\right]^{\frac{-\beta}{\sigma-1}}L^{\beta}=\left(\frac{\psi}{1-\beta}\right)\alpha^{\frac{-\varepsilon}{\varepsilon-1}}\left[1+K\right]^{\frac{-1}{\varepsilon-1}}$$

$$x_{Ht}^{-\beta}H^{\beta}=\left(\frac{\psi}{1-\beta}\right)(1-\alpha)^{\frac{-\varepsilon\beta}{\sigma-1}}H^{-\beta}\left[\frac{1+K}{K}\right]^{\frac{-\beta}{\sigma-1}}H^{\beta}=\left(\frac{\psi}{1-\beta}\right)(1-\alpha)^{\frac{-\varepsilon}{\varepsilon-1}}\left[\frac{1+K}{K}\right]^{\frac{-1}{\varepsilon-1}}$$

Using the two expressions above, the no-arbitrage condition can be re-written in the following way:

$$\eta_L\left(\frac{\psi}{1-\beta}\right)K\left[\frac{(1-\sigma)\varepsilon}{\sigma(\varepsilon-1)}\right]x_{Lt+1}+\eta_L\left[1+K\right]\left(\frac{\psi}{1-\beta}\right)\left\{1-\frac{(1-\beta)\mathrm{K}}{\sigma(1+\mathrm{K})}\right\}x_{Lt+1}-\eta_L\psi x_{Lt+1}=$$

$$\eta_H\left(\frac{\psi}{1-\beta}\right)\frac{1}{K}\left[\frac{(1-\sigma)\varepsilon}{\sigma(\varepsilon-1)}\right]x_{Ht+1}+\eta_H\left[\frac{1+K}{K}\right]\left(\frac{\psi}{1-\beta}\right)\left\{1-\frac{(1-\beta)}{\sigma(1+\mathrm{K})}\right\}x_{Ht+1}-\eta_H\psi x_{Ht+1}$$

We also know that $\frac{x_{Ht}}{x_{Lt}}=K\left(\frac{N_L}{N_H}\right)$. Plugging this and rearranging results in:

$$\eta_L\left(\frac{\psi}{1-\beta}\right)K\left[\frac{(1-\sigma)\varepsilon}{\sigma(\varepsilon-1)}\right]x_{Lt+1}+\eta_L\left[1+K\right]\left(\frac{\psi}{1-\beta}\right)\left\{1-\frac{(1-\beta)\mathrm{K}}{\sigma(1+\mathrm{K})}\right\}x_{Lt+1}-\eta_L\psi x_{Lt+1}=$$

$$\eta_H\left(\frac{\psi}{1-\beta}\right)\frac{1}{K}\left[\frac{(1-\sigma)\varepsilon}{\sigma(\varepsilon-1)}\right]K\left(\frac{N_L}{N_H}\right)x_{Lt+1}+$$

$$\eta_H\left[\frac{1+K}{K}\right]\left(\frac{\psi}{1-\beta}\right)\left\{1-\frac{(1-\beta)}{\sigma(1+\mathrm{K})}\right\}K\left(\frac{N_L}{N_H}\right)x_{Lt+1}-\eta_H\psi K\left(\frac{N_L}{N_H}\right)x_{Lt+1}$$

$$\left[\frac{-\varepsilon\beta}{\sigma(1-\beta)}\right]\left[\eta_L\,\mathrm{K}-\eta_H\left(\frac{N_L}{N_H}\right)\right]+\left(\frac{1+K}{1-\beta}\right)\left[\eta_L-\eta_H\left(\frac{N_L}{N_H}\right)\right]$$

$$+\left\{-\frac{1}{\sigma}\right\}\left[\eta_L\,\mathrm{K}-\eta_H\left(\frac{N_L}{N_H}\right)\right]=\eta_L-\eta_H K\left(\frac{N_L}{N_H}\right)$$

$$\left[\frac{-1}{(1-\beta)}\right]\left[\eta_L\,\mathrm{K}-\eta_H\left(\frac{N_L}{N_H}\right)\right]+\left(\frac{1+K}{1-\beta}\right)\left[\eta_L-\eta_H\left(\frac{N_L}{N_H}\right)\right]=\eta_L-\eta_H K\left(\frac{N_L}{N_H}\right)$$

Since the left hand side of the expression above involves the term $-1/(1-\beta)$, this equation can only be satisfied if both left and right hands sides are equal to zero. If the left hand side is equal to zero, than the following must be true:

$$\eta_L\,\mathrm{K}-\eta_H\left(\frac{N_L}{N_H}\right)=(1+K)\left[\eta_L-\eta_H\left(\frac{N_L}{N_H}\right)\right]$$

From this equation, the variable K can be obtained as

$$K=\left(\frac{\eta_L}{\eta_H}\right)\left(\frac{N_H}{N_L}\right)$$

This result also makes sure that the right hand side of the mentioned expression also is equal to zero as well. Therefore, the ratio of the number of technologies available across sectors in the social planner's setting can be found using

$$K \equiv \left(\frac{1-\alpha}{\alpha}\right)^{\frac{\epsilon}{\sigma}} \left(\frac{N_{Ht}}{N_{Lt}}\right)^{\frac{\sigma-1}{\sigma}} \left(\frac{H}{L}\right)^{\frac{\sigma-1}{\sigma}} = \left(\frac{\eta_L}{\eta_H}\right)\left(\frac{N_H}{N_L}\right)$$

$$\frac{N_{Ht}^{sp}}{N_{Lt}^{sp}} = \left(\frac{\eta_H}{\eta_L}\right)^{\sigma} \left(\frac{1-\alpha}{\alpha}\right)^{\varepsilon} \left(\frac{H}{L}\right)^{\sigma-1}$$

The expression above shows that the ratio of technologies available in each sector is actually constant across time in the socially planned economy. Therefore, the solution of the social planner's problem again takes place on a balanced growth path, that is in the socially planned economy every variable aside from the relative ratio of the number of machines available across sectors, i.e. N_{Ht}/N_{Lt}, all variables grow at the common growth rate g. This is because every variable can be expressed linearly in terms of N_{Lt} or N_{Ht}. Therefore, the budget constraint of the social planner can be described as:

$$C_0 g^t = \left[1+K\right]^{\frac{\varepsilon}{\varepsilon-1}} \alpha^{\frac{\varepsilon}{\varepsilon-1}} N_{Lt} x_{Lt}^{1-\beta} L^{\beta} - \psi\left[N_{Lt}x_{Lt} + KN_{Lt}x_{Lt}\right] - g\left(\frac{N_{Lt}}{\eta_L} + \frac{N_{Ht}}{\eta_H}\right)$$

$$C_0 g^t = \left\{\left[1+K\right]^{\frac{\varepsilon}{\varepsilon-1}} \alpha^{\frac{\varepsilon}{\varepsilon-1}} x_{Lt}^{-\beta} L^{\beta} - \psi\left[1+K\right]\right\} N_{Lt}x_{Lt} - g\left(\frac{N_{Lt}}{\eta_L} + \frac{N_{Ht}}{\eta_H}\right)$$

$$C_0 g^t = \left\{\left[1+K\right]^{\frac{\varepsilon}{\varepsilon-1}} \alpha^{\frac{\varepsilon}{\varepsilon-1}} \left(\frac{\psi}{1-\beta}\right) \alpha^{\frac{-\varepsilon}{\varepsilon-1}} \left[1+K\right]^{\frac{-1}{\varepsilon-1}} - \psi\left[1+K\right]\right\} N_{Lt}x_{Lt} - g\left(\frac{N_{Lt}}{\eta_L} + \frac{N_{Ht}}{\eta_H}\right)$$

$$C_0 g^t = \beta[1+K]\left(\frac{\psi}{1-\beta}\right) N_{Lt} x_{Lt} - g\left(\frac{N_{Lt}}{\eta_L}+\frac{N_{Ht}}{\eta_H}\right)$$

$$C_0 g^t = \beta[1+K]^{\frac{\sigma}{\sigma-1}}\left(\frac{\psi}{1-\beta}\right)^{\frac{\beta-1}{\beta}} L\alpha^{\frac{\epsilon}{\sigma}} N_{L0} g^t - g^{t+1}\left(\frac{N_{L0}}{\eta_L}+\frac{N_{H0}}{\eta_H}\right)$$

When the growth rates of the market equilibrium and social planner's setting are compared, it can be observed that the growth rate of in the socially planned is not the same rate obtained in the market economy:

$$g_{cp} = \mu\left\{1+\eta_L\left(\frac{\beta\psi}{1-\beta}\right)\left[\frac{(1-\beta)^2\left[1+\left(\frac{1-\alpha}{\alpha}\right)^{\epsilon}\left(\frac{H}{L}\right)^{(\epsilon-1)\beta}\left(\frac{\eta_H}{\eta_L}\right)^{(\epsilon-1)\beta}\right]^{\frac{1}{\epsilon-1}}\alpha^{\frac{\epsilon}{\epsilon-1}}}{\psi}\right]^{\frac{1}{\beta}} L\right\}$$

$$g_{sp} = \mu\left\{1+\eta_L[1+K]^{\frac{1}{\varepsilon-1}} K\left[\frac{(1-\sigma)\varepsilon}{\sigma(\varepsilon-1)}\right]\alpha^{\frac{\varepsilon}{\varepsilon-1}} x_{Lt+1}^{1-\beta} L^{\beta} + \eta_L[1+K]^{\frac{\varepsilon}{\varepsilon-1}}\alpha^{\frac{\varepsilon}{\varepsilon-1}} x_{Lt+1}^{1-\beta}L^{\beta}\left\{1-\frac{(1-\beta)\mathrm{K}}{\sigma(1+\mathrm{K})}\right\} - \eta_L\psi x_{Lt+1}\right\}$$

Therefore, solving the social planner's problem in order to describe the socially optimal allocations and comparing them to those obtained in the market economy yield important result. The first finding is that the demand for each type of machinery across the two sectors is strictly higher in the social planner's setting compared to the decentralized economy. The main reason for this finding is the fact that in the social planner's setting, the social planner does not charge a markup over the constant marginal cost of production for the machinery used in production, since in the socially optimal case the technology monopolists do not make any profits in practice. The rental price for each type of machinery is equal to its constant marginal cost of ψ .

Secondly, the ratio of the number of available technologies across the two sectors in the social planner's setting is actually equal to the one obtained in the decentralized equilibrium. This is expected, as the main source of inefficiency in the market economy is found to be the structure of the market of technology/machinery, which is monopolistically competitive. However, since the technology markets of the two sectors are both monopolistically competitive (that is the degree of competition is the same across skill-intensive and non-skill intensive technology markets), the number of available technologies across sectors in the market equilibrium is identical to its socially optimal level. If the market structure of the technology markets was not identical across the two sectors, then the ratio of the number of technologies available in the two sectors planned economy and market economy would differ from each other. Finally, growth rates and the level of aggregate output are different in the market economy compared to those obtained in the social planner's setting - which again stems from the monopolistically competitive nature of the technology market in the market economy.

1.3 Numerical simulations

In this section, the results of the numerical simulations regarding the performance of different intermediate good subsidization policies are compared. Specifically, the effects of changing the ratio of technologies available in two sectors by distorting the relative prices of intermediate goods through subsidies are simulated. During the numerical simulations, the following values are used for model parameters:

Table 1. Values of Model Parameters Used in the Numerical Simulation

Parameter	μ	β	α	τ	H	L	η_H	η_L	ε
Value	0.96	0.65	0.5	0.05	1.2	1.5	0.75	1.5	1.75

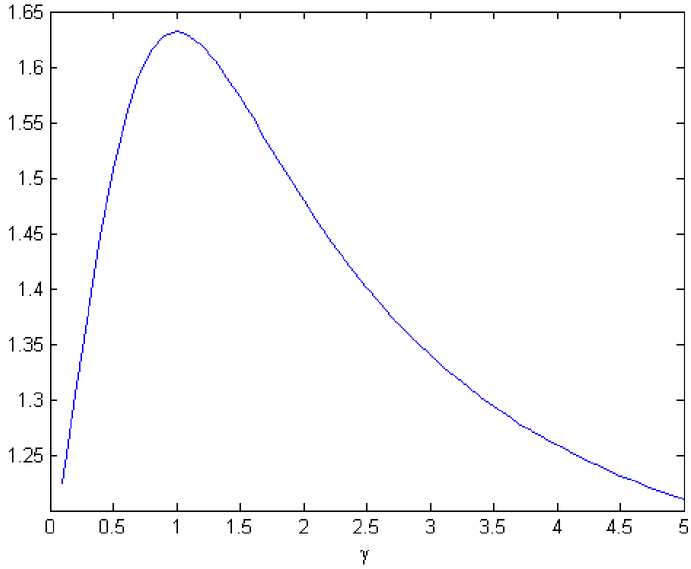

Fig. 1 Simulated growth levels

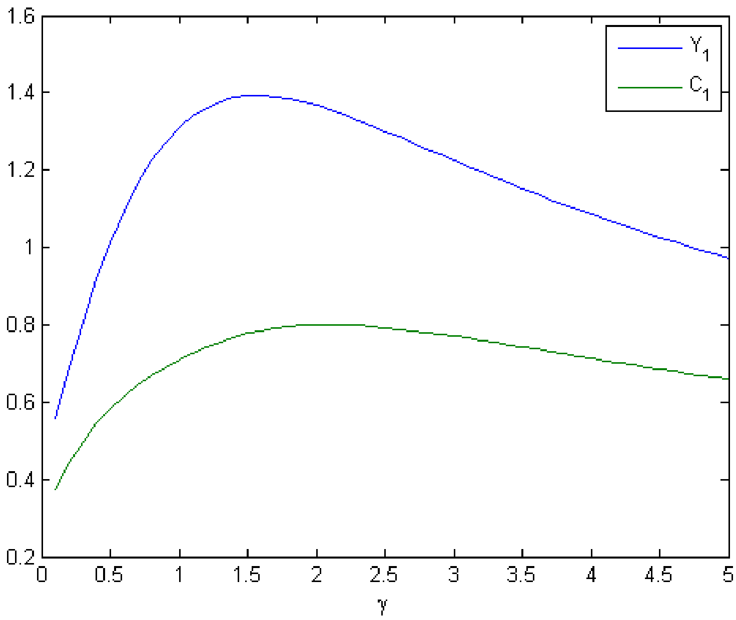

Fig. 2 Simulated aggregate output and consumption levels in the first period

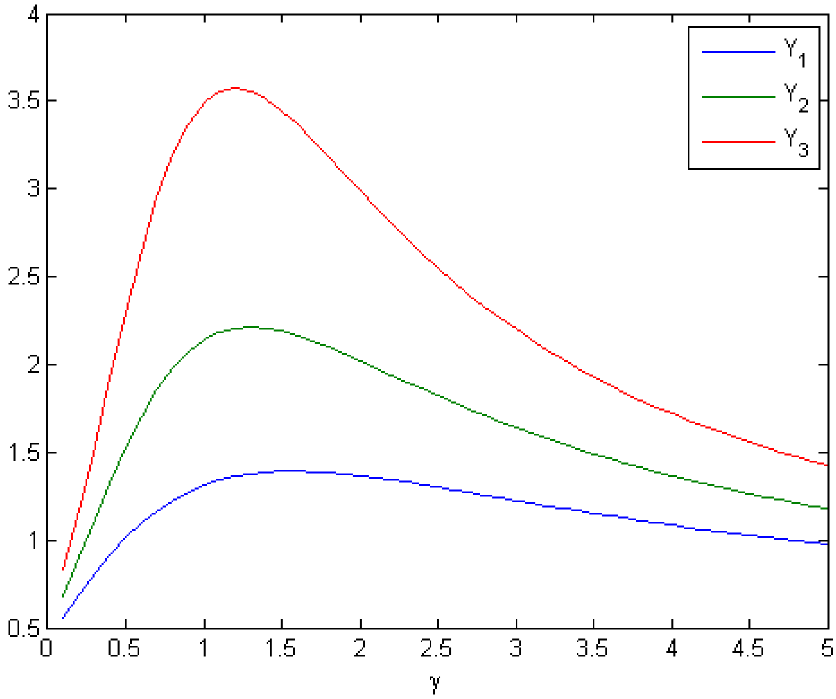

Fig. 3 Aggregate output in the first, second and third period under different policies

Results of the numerical simulations confirm the theoretical findings obtained in the previous section. The growth rate is maximized where the parameter γ is equal to one – where the relative number of technologies in the distorted market economy is equal to that of the undistorted market economy. The solution to the social planner's problem had already confirmed that the source of inefficiency in the model was not the discrepancy of the degree of technological development across sectors. In the market economy, both sectors were technologically backward compared to the socially optimal case at the same rate. Therefore, the optimal intermediate good subsidization policy simply turns out to be subsidizing the price of the intermediate good across two sectors at the same rate.

1.4 Conclusion

In this study, the potential role of government and the effects of various fiscal policies in a directed technical change setting – where the productivity of each factor of production is determined endogenously through the relative profitability of creating new inventions across sectors – are studied.

The theoretical analysis yields two important results. The first one is that, since technological markets are monopolistically competitive there is room for the government to conduct a corrective fiscal policy via subsidizing the price of intermediate goods in this environment. As the technological markets of the skilled and unskilled labor intensive sectors are assumed to be equally competitive (that is both markets are monopolistically competitive), the optimal fiscal policy involves the subsidization of the intermediate good prices across the two sectors at the same rate and keeping the relative prices of the intermediate goods constant at their decentralized equilibrium levels.

The second result is that if the subsidization policy is conducted in a way that favors one sector more than the other, that is if the price of the intermediate good of a sector is subsidized more than the other sector, the growth rate is severely affected. This stems from the fact that relative prices - hence the absolute prices of the intermediate goods (and consequently machinery demand) - are very sensitive to any government intervention that changes the equilibrium level of the relative number of technologies available across sectors. The results of the numerical simulations also support this theoretical finding.

CHAPTER 2

CENTRAL BANK INDEPENDENCE AND INFLATION

2.1 Introduction

Following the pioneering work of Rogoff (1985), which is based on earlier studies of Kydland and Presscott (1977) and Barro and Gordon (1983), extensive theoretical and empirical studies have been done suggesting that increasing central bank independence (CBI thereafter) decreases inflation, with little costs, if any. Cukierman (1992), Alesina and Summers (1993) are the most known studies among many others. Not surprisingly, beginning in late 1980's and through 1990's, governments throughout the world delegated more and more power to their central banks, making them more independent. However, more recent studies[1] examining the relationship between CBI and inflation raised doubts on the issue[2]. Recent empirical findings do not seem to find convincing evidence on this negative relationship. Some studies even went further claiming that in certain countries the relationship is positive.[3]

There are several arguments proposed to explain this non-negative or not significantly negative relationship between CBI and inflation. One argument by Ismihan and Ozkan (2004) is that increasing CBI may deliver low inflation in the short-run but it may also reduce the scope for productivity enhancing public investment and produce higher inflation in the long run. This argument is not convincing because huge falls in public investment after monetary policy reforms are

[1] Hayo and Hefeker (2008) and to some extent Acemoglu et.al. (2008) provide surveys of these literature.
[2] See for example Posen (1993), Eijffinger and Schalin(1998), Forder (1998) Daunfeldt and De Luna (2008).
[3] For example see Hillmann (1999), Campillo and Miron (1997) and King and Ma (2001).

done have not been observed frequently, and there is evidence that it raises private investment. (Pastor and Maxfield (1999))

More recently, Acemoglu et.al. (2008) developed a model where they tie this discussion to political constraints and institutional quality. They argue that monetary policy reform have modest effects, if any, in societies where political constraints on the executives are low or high. According to them, it works best in societies with intermediate constraint. Moreover, they identify an effect, which they call as the seesaw effect, to illustrate the fact that once a policy is reformed other policies may deteriorate.

Again, why does the CBI not have a (significant) negative effect on inflation? The hypothesis suggested in this paper to answer this question is that changing the CBI has two effects working in opposite directions at the same time. One of them is the direct effect of CBI, which is called as the delegation effect. This effect is related to the literature starting with Rogoff (1985). As monetary policy is delegated from the government to an institution which dislikes inflation more (such as a conservative central bank) than the government, then time inconsistency problem becomes less severe, the growth rate of money supply goes down and that is why the direct effect should be negative on inflation. However, what if the government tries to exploit other policy tools to affect inflation, as it delegates monetary policy to the central bank? This is yet another effect, which is called as the seesaw effect. As the CBI increases (or monetary policy reform is being done), other dimensions of policy might deteriorate.

In this paper an empirical documentation will be provided regarding a hypothesis suggesting that the deterioration in fiscal policy (the seesaw effect), which might have adverse effects on inflation, can offset the gains from the delegation effect. Then, a game theoretical model, which accounts for this empirical observation will be presented.

The theoretical model consists of two policy-makers: A conservative central bank (monetary authority) which determines the level of money supply and a government (fiscal authority) which sets the fiscal policy. Inflation is determined by the joint actions of the policy-makers[4]. Moreover, the government holds a private information on its marginal cost of fiscal expansion. Basically, the model is an adverse selection model with the central bank as the proposer and the government as the responder. As the CBI goes up, the delegation effect decreases the contribution of monetary policy to inflation, whereas at the same time the government starts to exploit the fiscal policy to increase inflation (the seesaw effect). The net effect of increasing CBI on inflation depends on the severity of information asymmetry between the government and the central bank.

The organization of this paper is as follows: In the next section, some empirical observations will be discussed to motivate the theoretical model. There, the suggested hypothetical mechanism will be tested empirically and evidence for the existence of the two effects will be provided. Section 3 presents the structure of the theoretical model, together with the solution of the model under both complete and incomplete information cases. Finally, concluding remarks are offered in Section 4.

2.2 Empirical motivation

This section consists of three subsections. In the first one, the construction of the data sample used in this study will be elaborated. In the second one, using this sample, the relationship between CBI and inflation will be illustrated and estimated. In the last

[4] By conservative I mean a central bank which dislikes inflation relatively more than the government.

subsection, the theoretical hypothesis about the mechanism behind this relationship will be provided and tested empirically.

2.2.1 Data sources

To test the interaction of fiscal and monetary policies and their joint effects on inflation, a panel data of CBI, inflation and public deficits as a percentage of GDP with 80 countries (25 developed economies and 55 developing countries) spanning over 12 years, from 1989 to 2000 is used. The annual variation in the consumer price index documented in International Financial Statistics (IMF) is used as the annual inflation rate. For public deficit, the data of Catao and Terrones(2005) is employed.[5] To measure the CBI, different approaches have been used in the literature.[6] Each approach has different drawbacks.[7] Acemoglu et.al. (2008) argues that the current state of the art of the measurement of de jure CBI stems from Cukierman (1992) and Cukierman, Webb and Neyapti (1992). Actually, it is not only the state of the art index but also the one people used and discussed extensively in the literature.[8] The data used in this study for central bank independence is taken from two different resources: One is Polillo and Guillen (2005) where the authors extended the one-year cross-country data of Cukierman (1992) for a 12-year period. In order to control for potential drawbacks of this measure, in a similar fashion as Acemoglu et.al (2008), a robustness check is also employed by measuring the CBI, in an alternative way, by a dummy variable which becomes 1 or 0 in each year depending on whether the year

[5] Thanks to the authors' generosity
[6] Examples are Alesina (1988), Grilli, Masciandaro and Tabellini (1991), Eijffinger and Schaling (1992) and Cukierman (1992)
[7] See Acemoglu et.al. (2008), and Mangano (1998) for a comprehensive discussion and comparison of different indices developed to measure the CBI.
[8] de Haan and Sikken (1998), Eijffinger and de Haan (1996), Eijffinger, Schaling and Hoeberichts (1998) and Neyapti (2003) among many others.

considered is after the central bank reform or not. The data of this dummy variable is taken from the appendix of Acemoglu et.al. (2008). This paper also provides an extensive discussion of this and many other approaches to constructing a CBI index. The results of the regression analysis will be shown to be invariant with respect to this change in the CBI index.

2.2.2 Inflation and central bank independence

Building upon the theoretical work by Rogoff (1985), many empirical studies have argued a negative relationship between CBI and inflation dominated the literature,[9] whereas there are also several studies questioning this relationship.[10] More recently Acemoglu et.al. (2008) presented and empirically tested a model where the main finding is that CBI has differential effects on inflation, these effects depending broadly speaking on institutions.

Now, for the panel data regression of inflation on CBI, the following equation is estimated:

$$\pi_{i,t} = \sum_{k=1}^{n} \alpha_k \pi_{i,t-k} + \beta_0 I_{i,t} + \sum_{k=1}^{n} \beta_k I_{i,t-k} + \theta_i + \gamma_t + \epsilon_{i,t}$$

where $\pi_{i,t}$ stands for the inflation in country i in year t and $I_{i,t}$ for the CBI. Since CBI may have lagged effects on inflation, the lagged values for it are also controlled for. Similarly, including lagged variables of inflation in the equation allows checking

[9] See Alesina and Summers (1993), Cukierman (1992), Cukierman, Miller and Neyapti (2002) Loungani and Sheets (2002) among others.

[10] Banian, Burdekin and Willett (1998) and Hillmann (1999), de Haan and Kooi (2000) are some of examples of this view. See Hayo and Hefeker (2007) for a detailed survey of both views in empirical and theoretical studies.

for serial correlation. Where the lagged variables stop to be statistically significant, they cease to be included in the equation. Lastly, θ_i and γ_t correspond to the country and period dummies, respectively. Including them will permit checking the fixed effects in the panel data estimation.[11] The last term in the equation is the error term. Table 2 presents the results for the panel data estimation for three groups of countries: Developed, developing and all.

Table 2. OLS Fixed Effects Regressions of Inflation on CBI

	Developed Countries	Developing Countries	Full Sample
Constant	20.71	42.06	20.54
	(13.10)	(24.03)	(20.19)
CBI Coefficient	13.12	28.26	25.12
	(20.12)	(30.12)	(30.17)
R-squared	0.38	0.38	0.21
Observations	210	701	923

All OLS regressions include year and country fixed effects. Standard deviations are reported below the coefficient in parentheses. Each sample considered is an unbalanced panel with one observation per country per year. The coefficients of the lagged variables are not reported in the table.

According to the table 2, even though the positive coefficients are not statistically significant, one can reject the null hypotheses that they are negative. So at least, it is possible to say that the negative relationship between CBI and inflation is not supported in my sample. Also, notice that the t-statistic for the positive coefficients are highest in the sample with developing countries only and lowest in the sample for developed countries only.

To summarize, the empirical analysis so far clearly shows that the argument for the negative relationship between CBI and inflation is not supported in the data, which is also in compliance with the recent findings that have been documented in the previous section of the paper.

[11] I am aware of the fact that the strict exogeneity assumption does not need to hold here and the possibility of having serial correlation in the error terms.Obviously, the regression equation does not imply causality. I just want to document the relationship between CBI and inflation.

2.2.3 Seesaw and delegation effects

To motivate the hypothesis stated in the introduction, the two distinct effects of CBI on inflation will be separated. As it has already been explained, one effect is the delegation effect, the direct effect of CBI on inflation (which is negative) and the other one is the seesaw effect through deterioration of the fiscal policy (which is positive). The argument that will be test in this subsection will be that the total effect of CBI on inflation will be non-negative if the direct effect of the increase in CBI (delegation effect) is offset by increasing public deficits (seesaw effect).

Before separating the effects, as CBI goes up, one first needs to check whether public balance really worsens or not.[12] Table 3 documents the results of running the following regression of budget balance on the CBI:

$$B_{i,t} = \sum_{k=1}^{n} \chi_k B_{i,t-k} + \kappa_0 I_{i,t} + \sum_{k=1}^{n} \kappa_k I_{i,t-k} + \mu_i + \omega_t + u_{i,t}$$

where $B_{i,t}$ stands for the budget balance in country i in year t. Again, the effects of the lagged variables $B_{i,t-k}$ and $I_{i,t-k}$ are controlled for. μ_i and ω_t capture the country and period fixed effects. As one can check from table 3, the sign of κ_0 is negative, i.e. a higher CBI is associated with a lower budget balance, or higher budget deficit. Also, notice that the coefficients are significant at 5% for the whole sample and for the sample with developing countries. For developed countries, the negative coefficient is significant at 10%.

[12] Even tough I run regressions by regressing inflation on public balance I do not spend time to document this relation because Catao and Terrones (2005) have already documented it for a very large sample. They find that as the budget balance worsens inflation increases.

Table 3. OLS Fixed Effects Regressions of Budget Balance on CBI

	Developed Countries	Developing Countries	Full Sample
Constant	-0.12	-2.1	-2
	(0.07)	(1.03)	(1.19)
CBI Coefficient	13.12	-28.26	-25.12
	(10.12)	(14.12)	(10.17)
R-squared	0.21	0.29	0.24
Observations	214	712	925

All OLS regressions include year and country fixed effects. Standard deviations are reported below the coefficient in parentheses. Each sample considered is an unbalanced panel with one observation per country per year. The coefficients of the lagged variables are not reported in the table.

Now, to separate the two effects, the coefficient representing the effect of CBI on inflation will be assumed to exhibit the following functional form[13]:

$$\beta_0 = \phi_1 + \phi_2 B_{i,t}$$

What this equation hypothesizes is that the effect of CBI on inflation depends on the budget balance B[14]. Then the regression equation becomes as follows:

$$\pi_{i,t} = \sum_{k=1}^{n} \alpha_k \pi_{i,t-k} + \phi_1 I_{i,t} + \phi_2 I_{i,t} B_{i,t} + \sum_{k=1}^{n} \beta_k I_{i,t-k} + \theta_i + \gamma_t + \varepsilon_{i,t}$$

In this way, it is possible to identify the two effects to some extent. ϕ_1 stands for the delegation effect and it is expected to be negative. On the other hand, ϕ_2 will show the degree of the seesaw effect. As the budget balance worsens (i.e. as B goes down) β_0 is expected to increase. In other words, deteriorating budget balance should increase β_0, hence inflation. That is why ϕ_2 is also expected to be negative. Table 4

[13] Kennedy (2000) devotes a subsection on models with coefficients depending on an explanatory variable lists many papers related to this.

[14] Our model in the benchmark case will produce a similar result in the next section.

presents the results of running this regression, again for different sets of countries: developed, developing and all. The crucial result of this estimation is that now it is possible to observe the two distinct and opposite effects very clearly. The coefficients of CBI are all clearly negative in different samples and all of them are also significant at 5%. The coefficient of the product of CBI and budget balance is also as expected even though they are not significant at 5% for the sample for developing countries and the whole sample. This result is suspected to stem from the fact that the government's ability to exploit fiscal policy is rather limited in developed economies, compared to developing ones. But still it is possible to visualize the two distinct effects working in opposite directions.

Table 4. OLS Fixed Effects Regressions of Inflation on CBI and Budget Balance*CBI

	Developed Countries	Developing Countries	Full Sample
Constant	32.12	53.1	54
	(10.07)	(15.03)	(1.19)
CBI Coefficient - 330.12	-280.26	-317.02	
	(100.12)	(40.12)	(147.17)
CBI*Budget Balance	-113:12	-128.26	-120.44
	(60.12)	(64.12)	(66.52)
R-squared	0.21	0.29	0.21
Observations	202	702	904

All OLS regressions include year and country fixed effects. Standard deviations are reported below the coefficient in parentheses. Each sample considered is an unbalanced panel with one observation per country per year. The coefficients of the lagged variables are not reported in the table

2.3 The theoretical model

The micro-founded model underlying this analysis is a modified version of the model in Dixit and Lambertini (2003). The model has monopolistic competition and staggered price setting. Monopolistic power of firms leads the aggregate output to be below its desired level. Both monetary policy and fiscal policy are available to counter the monopoly distortion. The staggered prices let monetary policy to have real effects.

After solving the micro-founded model and log-linearizing the variables around the steady state, the following equations are obtained on which the proceeding analysis is based:

$$y = \underline{y} + \lambda x + \alpha\left(\pi - \pi^e\right)$$

$$\pi = \sigma\mu + \theta x$$

where y is the aggregate output, $\underline{y}$ is the level of output in the absence of any corrective policy. π is the realized inflation, π^e is the rational expectation of π, μ is the monetary policy variable, x is the fiscal policy variable, θ is the inflation coefficient of x and λ is the fiscal multiplier parameter. Unexpected inflation increases the output; so $\alpha > 0$.

2.3.1 The policy game between the government and the central bank

There are two policy-makers in the economy: the central bank (as the monetary authority) and the government (as the fiscal authority). They move after the private sector sets the inflation expectation, π^e, and cannot commit to a policy before the expectations are set. The central bank chooses the monetary variable, μ, and the government chooses the fiscal variable, x. The central bank has a given level of autonomy from the government. This level is represented by a fixed cost $F \in \left[F_{min}, F_{max}\right]$ (where $0 \le F_{min} \le F_{max} < \infty$), that the government must pay in order to overrule the central bank's decision. The government's payoff function is given by:

$$R^G = -\frac{1}{2}\left(y - y^n\right)^2 - \delta x$$

y^n is the government's output target and δ is a parameter measuring the constant marginal cost (or disutility) of fiscal expansion for the government. The central bank's payoff is given by:

$$R^{CB} = -\frac{1}{2}\pi^2$$

Here, an informational asymmetry is introduced to the model via assuming that the government is a random variable that can take two values, that is $\delta \in \left\{\underline{\delta}, \overline{\delta}\right\}$ where $0 < \underline{\delta} < \overline{\delta} < \infty$. Therefore, fiscal expansion may be preferred at varying degrees across different types of government. However, it is also assumed that the exact value of δ is the private information of the government. The central bank has only a prior that the probability of facing a government the type $\underline{\delta}$ is p where $0 \le p \le 1$.

The timing of the policy game is as follows: (0) Rational inflation expectation π^e is set. (1) The central bank chooses the monetary policy, μ , which is a function of the fiscal policy variable x. (2) The nature chooses the type of the government, δ . (3) The government decides to accept or reject the monetary policy. (3.i) If the policy is accepted, the government decides the fiscal policy variable x and receives μ . (3.ii) If it is rejected, the government pays a fixed cost of F, and sets both the monetary policy and the fiscal policy variables, $\left(\mu, x\right)$ on its own. (4) Finally, π , y and, hence, the payoffs are realized. Figure 4 illustrates the game and the timing of events.

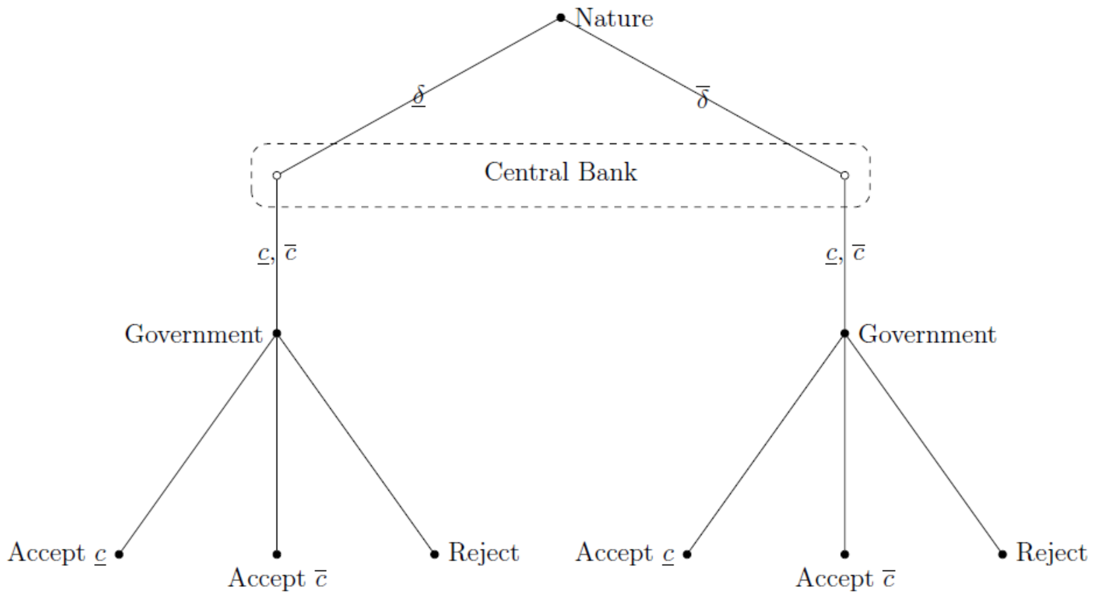

Fig. 4 Game tree describing the timing of events

Given the central bank's choice of monetary policy, μ , if the government of type δ decides to accept the policy, it gets the payoff:

$$R^G_{accept}(\delta) \equiv max_x R^G(x,\mu,\delta)$$

If the government rejects the monetary policy μ and sets a policy $(\mu_{reject}, x_{reject})$, then its payoff becomes

$$R^G_{reject}(\delta) \equiv max_{\{\mu_{reject}, x_{reject}\}} R^G(x_{reject}, \mu_{reject}, \delta)$$

The government accepts the monetary policy if and only if

$$R^G_{accept}(\delta) \geq R^G_{reject}(\delta) - F$$

Given the government's strategy, the central bank's objective is to choose the monetary policy function μ to maximize

$$E\left[R^{CB}\left(x,\mu,\delta,p\right)\right]=R^{CB}\left(x,\mu,\underline{\delta}\right)p\left(\underline{\delta}\right)+R^{CB}\left(x,\mu,\bar{\delta}\right)p\left(\bar{\delta}\right)$$

2.3.2 The complete information case

In this subsection, the central bank is assumed to know the type of the government with respect to the marginal cost of fiscal expansion, that is central bank knows the parameter δ with certainty. While this is a substantial simplification of the model, it helps to identify the two distinct effects of a change in the degree of central bank independence, namely delegation and seesaw effects, very clearly.

The model is solved via backward induction. First, the final stage of the game is solved - where given the monetary policy offer from the central bank. At this stage, the government makes two decisions. The first decision is between rejecting and accepting the central bank’s monetary policy offer. The second decision is related to the determination of the optimal fiscal and monetary policies in the case of rejecting the central bank’s policy offer, paying the fixed cost F associated with circumventing the central bank’s authority in monetary policy and choosing monetary and fiscal policies that maximize its return.

First start with the second decision in the final stage of the game, which is the determination of the optimal fiscal and monetary policies in the case of rejecting the central bank’s offer. In this case, the government chooses $\left(\mu_{reject},x_{reject}\right)$ that satisfies the following:

$$\left(\mu_{reject}, x_{reject}\right) \in argmax_{\{\mu_{reject}, x_{reject}\}} R^G_{reject}\left(\delta\right) = -\frac{1}{2}\left(y - y^n\right)^2 - \delta x_{reject} - F$$

From the previous section, $y = \underline{y} + \lambda x + \alpha\left(\pi - \pi^e\right)$ and $\pi = \sigma\mu + \theta x$ are also known. Therefore, the government's return function in the case of rejection can be re-written in the following way:

$$R^G_{reject}\left(\delta\right) = -\frac{1}{2}\left[\underline{y} + \lambda x_{reject} + \alpha\left(\sigma\mu_{reject} + \theta x_{reject} - \pi^e\right) - y^n\right]^2 - \delta x_{reject} - F$$

Taking the first order condition of this unconstrained maximization problem yields the following:

$$\frac{\partial R^G_{reject}}{\partial \mu_{reject}} :- \left[\underline{y} + \lambda x_{reject} + \alpha\left(\sigma\mu_{reject} + \theta x_{reject} - \pi^e\right) - y^n\right] a\sigma = 0$$

$$\frac{\partial R^G_{reject}}{\partial x_{reject}} :- \left[\underline{y} + \lambda x_{reject} + \alpha\left(\sigma\mu_{reject} + \theta x_{reject} - \pi^e\right) - y^n\right]\left(\lambda + a\theta\right) - \delta = 0$$

Here first assume $y^n - \underline{y} + \alpha\pi^e > 0$ (that is, if the government does not adopt any corrective policies, than the realized output is below the targeted output level) and define $K \equiv y^n - \underline{y} + \alpha\pi^e$ (which measures the output gap in the absence of any corrective policy). Notice that without imposing an upper bound on the interval of the monetary policy variable, this maximization problem results in:

$$\mu^*_{reject} = \frac{K}{\alpha\sigma}$$

$x^{*}_{reject} = 0$

The intuition behind this result is very simple. The government's objective involves minimizing the output gap with as little fiscal cost as possible. While the marginal cost of fiscal expansion is positive (i.e. $\delta > 0$), monetary expansion is costless. Therefore, without any limits on the monetary expansion choice of the government, the government chooses to eliminate the output gap only with monetary expansion. In order to prevent this result, an upper bound on the interval of the monetary policy variable must be imposed. Therefore, suppose that $\mu \in [\mu_{min}, \mu_{max}]$ where $\mu_{max} < K / \alpha\sigma$. This ensures that now the government cannot eliminate the output gap completely using only monetary expansion, and its optimal policy mix will now include a positive level of fiscal expansion as well. Again, the government will choose the maximum level of monetary expansion it is allowed to choose, and then eliminate the remaining output gap with fiscal policy. Therefore in this case the optimal monetary policy will be:

$\mu^{*}_{reject} = \mu_{max}$

However, there are now two candidate optimal fiscal expansion levels given by:

$$x'_{reject} = \frac{K - \alpha\sigma\mu_{max}}{\lambda + \alpha\theta}$$

$$x''_{reject} = \frac{K - \alpha\sigma\mu_{max}}{\lambda + \alpha\theta} - \frac{\delta}{(\lambda + \alpha\theta)^2}$$

In order to find which candidate fiscal policy is the optimal one, evaluate the government's returns in each case:

$$R^G_{reject}\left(x^{'}_{reject},\mu_{max},\delta\right)=-\frac{\delta\left(K-\alpha\sigma\mu_{max}\right)}{\lambda+\alpha\theta}-F$$

$$R^G_{reject}\left(x^{''}_{reject},\mu_{max},\delta\right)=\frac{1}{2}\left[\frac{\delta}{\lambda+\alpha\theta}\right]^2-\frac{\delta\left(K-\alpha\sigma\mu_{max}\right)}{\lambda+\alpha\theta}-F$$

Since the term $\frac{1}{2}\left[\frac{\delta}{\lambda+\alpha\theta}\right]^2>0$, the optimal level of fiscal expansion in the case where central bank's offer is rejected corresponds to the second fiscal policy candidate. That is, the government receives a lower return with the second candidate fiscal policy because now the realized level of output has exceed the targeted level. Thus, the solution to the government's problem becomes:

$$\mu^*_{reject}=\mu_{max}$$

$$x^*_{reject}=\frac{K-\alpha\sigma\mu_{max}}{\lambda+\alpha\theta}-\frac{\delta}{\left(\lambda+\alpha\theta\right)^2}$$

Government's return from rejecting the central bank's monetary policy offer is therefore the following:

$$R^G_{reject}\left(x^*_{reject},\mu^*_{reject},\delta\right)=\frac{1}{2}\left[\frac{\delta}{\lambda+\alpha\theta}\right]^2-\frac{\delta\left(K-\alpha\sigma\mu_{max}\right)}{\lambda+\alpha\theta}-F$$

After establishing these results, government's behavior in the case where it accepts the central bank's offer should be analyzed. In this case, given the central bank's monetary policy decision, the government maximizes its return by choosing the optimal fiscal policy level. The optimal fiscal policy choice must satisfy the following:

$$x_{accept}^{*} \in argmax_{\{x_{accept}\}}\ R_{accept}^{G}\left(\delta\right) = -\frac{1}{2}\left(y - y^{n}\right)^{2} - \delta x_{accept}$$

In this case, government's return function takes the following form:

$$R_{accept}^{G}\left(x_{accept}, \mu, \delta\right) = -\frac{1}{2}\left[-K + \alpha\sigma\mu\left(x_{accept}\right) + \left(\lambda + \alpha\theta\right)x_{accept}\right]^{2} - \delta x_{accept}$$

The first order condition with respect to fiscal policy yields:

$$\frac{\partial R_{accept}^{G}}{\partial x_{accept}} :- \left[-K + \alpha\sigma\mu\left(x_{accept}\right) + \left(\lambda + \alpha\theta\right)x_{accept}\right]\left(\alpha\sigma\frac{\partial\mu}{\partial x} + \lambda + \alpha\theta\right) - \delta = 0$$

The first order condition of the government's return function with respect to its fiscal policy choice now potentially involves the derivative of the central bank's policy offer with respect to the government's fiscal policy choice, i.e. $\frac{\partial \mu}{\partial x}$. Here, we will prove that in fact this derivative is zero. The intuition behind this is not that central bank's policy offer does not depend on government's fiscal behavior, but that the central bank is actually already offering the optimal monetary policy associated with the government's fiscal decision. The formal proof of this result starts with the rearrangement of the first order condition given above and evaluating it at an arbitrary fiscal policy choice x:

$$K = \alpha\sigma\mu(x) + (\lambda + \alpha\theta)x - \frac{\delta}{\alpha\sigma\frac{\partial\mu}{\partial x} + (\lambda + \alpha\theta)}$$

Now evaluate this implicit expression between the monetary and fiscal policies at $x' = x + \Delta x$. The monetary policy μ accommodates to this change, and at the new equilibrium, this implicit expression again holds. Therefore:

$$K = \alpha\sigma\mu(x + \Delta x) + (\lambda + \alpha\theta)(x + \Delta x) - \frac{\delta}{\alpha\sigma\left.\frac{\partial\mu}{\partial x}\right|_{x=x+\Delta x} + (\lambda + \alpha\theta)}$$

Subtracting the first order condition evaluated at x from the one evaluated at $x' = x + \Delta x$ results in:

$$0 = \alpha\sigma\left[\mu(x + \Delta x) - \mu(x)\right] + (\lambda + \alpha\theta)\Delta x - \frac{\delta\alpha\sigma\left(\left.\frac{\partial\mu}{\partial x}\right|_{x=x} - \left.\frac{\partial\mu}{\partial x}\right|_{x=x+\Delta x}\right)}{\left[\alpha\sigma\left.\frac{\partial\mu}{\partial x}\right|_{x=x} + (\lambda + \alpha\theta)\right]\left[\alpha\sigma\left.\frac{\partial\mu}{\partial x}\right|_{x=x+\Delta x} + (\lambda + \alpha\theta)\right]}$$

Re-arranging the expression above and dividing both sides with Δx gives the following:

$$\frac{\delta\alpha\sigma\left[\dfrac{\left.\dfrac{\partial\mu}{\partial x}\right|_{x=x}-\left.\dfrac{\partial\mu}{\partial x}\right|_{x=x+\Delta x}}{\Delta x}\right]}{\left[\alpha\sigma\left.\dfrac{\partial\mu}{\partial x}\right|_{x=x}+(\lambda+\alpha\theta)\right]\left[\alpha\sigma\left.\dfrac{\partial\mu}{\partial x}\right|_{x=x+\Delta x}+(\lambda+\alpha\theta)\right]}=(\lambda+\alpha\theta)+\alpha\sigma\frac{\left[\mu(x+\Delta x)-\mu(x)\right]}{\Delta x}$$

Taking the limit of both hand sides yields:

$$\lim_{\Delta x\to 0}\frac{\delta\alpha\sigma\left[\dfrac{\left.\dfrac{\partial\mu}{\partial x}\right|_{x=x}-\left.\dfrac{\partial\mu}{\partial x}\right|_{x=x+\Delta x}}{\Delta x}\right]}{\left[\alpha\sigma\left.\dfrac{\partial\mu}{\partial x}\right|_{x=x}+(\lambda+\alpha\theta)\right]\left[\alpha\sigma\left.\dfrac{\partial\mu}{\partial x}\right|_{x=x+\Delta x}+(\lambda+\alpha\theta)\right]}=\lim_{\Delta x\to 0}(\lambda+\alpha\theta)+\alpha\sigma\frac{\left[\mu(x+\Delta x)-\mu(x)\right]}{\Delta x}$$

This permits me to re-write this expression

$$\frac{\alpha\sigma\delta}{\left[\alpha\sigma\dfrac{\partial\mu}{\partial x}+(\lambda+\alpha\theta)\right]^2}\frac{\partial^2\mu}{\partial x^2}=\left[\alpha\sigma\left.\frac{\partial\mu}{\partial x}\right|_{x=x}+(\lambda+\alpha\theta)\right]$$

$$\frac{\partial^2\mu}{\partial x^2}=\frac{\left[\alpha\sigma\left.\dfrac{\partial\mu}{\partial x}\right|_{x=x}+(\lambda+\alpha\theta)\right]^3}{\alpha\sigma\delta}$$

Now define the function $f(x)=\alpha\sigma\mu(x)+(\lambda+\alpha\theta)x$. Then the first order condition above can be re-written in the following way:

$$K=f(x)+\frac{\delta}{\dfrac{\partial f}{\partial x}}$$

Also note that $\frac{\partial f}{\partial x} = \alpha\sigma \frac{\partial \mu}{\partial x} + (\lambda + \alpha\theta)$ and $\frac{\partial^2 f}{\partial x^2} = \alpha\sigma \frac{\partial^2 \mu}{\partial x^2}$. Using these we can re-write the second derivative of the monetary policy in the terms of the derivatives of the function $f(x)$:

$$\frac{\partial^2 f}{\partial x^2} = \frac{\left(\frac{\partial f}{\partial x}\right)^3}{\delta}$$

The condition above can only be satisfied if the function $f(x)$ is actually a constant function, that is $f(x) = c\,\forall x \in R$. However, then we would arrive at a contradiction because $K = f(x) + \delta / (\partial f / \partial x)$ would not be possible to satisfy since the right hand side of the equation would go to infinity, whereas K is a finite and constant real number. Therefore, the central bank's monetary policy offer does not take the form of $\mu(x)$, but it is actually a constant number μ .

After establishing this result, given the central bank's monetary policy offer, when the government accepts this offer the optimal fiscal policy becomes:

$$x^*_{accept} = \frac{K - \alpha\sigma\mu}{\lambda + \alpha\theta} - \frac{\delta}{(\lambda + \alpha\theta)^2}$$

Using this information, government's return from accepting the central bank's offer can be calculated as:

$$R^{G}_{accept}\left(x_{accept},\mu,\delta\right)=\frac{1}{2}\left[\frac{\delta}{\lambda+\alpha\theta}\right]^{2}-\delta\left(\frac{K-\alpha\sigma\mu}{\lambda+\alpha\theta}\right)$$

From the previous analysis, the government was found to choose $\mu^{*}_{reject}=\mu_{max}$ and $x^{*}_{reject}=\frac{K-\alpha\sigma\mu_{max}}{\lambda+\alpha\theta}-\frac{\delta}{\left(\lambda+\alpha\theta\right)^{2}}$ when it rejects the central bank's offer. The return from rejection was found to be

$$R^{G}_{reject}\left(x^{*}_{reject},\mu^{*}_{reject},\delta\right)=\frac{1}{2}\left[\frac{\delta}{\lambda+\alpha\theta}\right]^{2}-\frac{\delta\left(K-\alpha\sigma\mu_{max}\right)}{\lambda+\alpha\theta}-F\ .$$

The government decides to accept the central bank's offer if the following is satisfied:

$$R^{G}_{accept}\left(x_{accept},\mu,\delta\right)\geq R^{G}_{reject}\left(x^{*}_{reject},\mu^{*}_{reject},\delta\right)$$

$$\frac{1}{2}\left[\frac{\delta}{\lambda+\alpha\theta}\right]^{2}-\delta\left(\frac{K-\alpha\sigma\mu}{\lambda+\alpha\theta}\right)=\frac{1}{2}\left[\frac{\delta}{\lambda+\alpha\theta}\right]^{2}-\frac{\delta\left(K-\alpha\sigma\mu_{max}\right)}{\lambda+\alpha\theta}-F$$

Rearranging this expression results in:

$$\mu^{*}=\mu_{max}-\frac{F\left(\lambda+\alpha\theta\right)}{\alpha\sigma\delta}$$

$$x^{*}=\frac{K-\alpha\sigma\mu_{max}}{\lambda+\alpha\theta}-\frac{\delta}{\left(\lambda+\alpha\theta\right)^{2}}+\frac{F}{\delta}$$

The optimal monetary fiscal policy is positively correlated with the degree of central bank independence, $\left(\frac{\partial x^*}{\partial F} > 0\right)$, which corresponds to the seesaw effect that is defined in the previous section. On the other hand, the level of monetary expansion seems to be negatively correlated with the degree of central bank independence, $\left(\frac{\partial \mu^*}{\partial F} < 0\right)$, which corresponds to the delegation effect. However, as fiscal expansion affects output both directly and indirectly through the inflation channel, the magnitude of the seesaw effect is always smaller than the magnitude of the delegation effect. Therefore, when the degree of central bank independence increases inflation unambiguously falls in the complete information case.

2.3.3 The incomplete information case with multiple government types

In this section, the government is allowed to lie about its type. However, if there is an agreement between both parties when the government lies about its type and receives the monetary policy associated with the opposite government type in return of the fiscal policy associated with the opposite type, the central bank can enforce the government to make the fiscal expansion associated with the opposite type.

Again, the government can be one of two types: $\delta_i \in \{\underline{\delta}, \overline{\delta}\}$ where $\underline{\delta} < \overline{\delta}$, that is fiscal expansion is more costly for one type of government. The government knows its type. The central bank does not possess this private information regarding the type of the government, but has a prior that $Prob(\delta_i = \underline{\delta}) = p$. Furthermore, $\mu \in [\mu_{min}, \mu_{max}]$ with $\mu_{max} < K/\alpha\sigma$.

First, inspect the participation decision of the government with $\delta_i \in \{\underline{\delta}, \bar{\delta}\}$.

For the government with δ_i the return from rejecting participation is the following:

$$R^G_{reject}(\delta_i) = -\frac{1}{2}[\underline{y} + \lambda x_{reject}(\delta_i) + \alpha\theta x_{reject}(\delta_i) + \alpha\sigma\mu_{reject}(\delta_i) - \pi^e - y_n]^2 - \delta_i x_{reject}(\delta_i)$$

The first order conditions with respect to x_i and μ_i are the following:

$$\frac{\partial R^G_{reject}(\delta_i)}{\partial x_{reject}(\delta_i)} = -\frac{1}{2}[\underline{y} + \lambda x_{reject}(\delta_i) + \alpha\theta x_{reject}(\delta_i) + \alpha\sigma\mu_{reject}(\delta_i) - \pi^e - y_n]2(\lambda + \alpha\theta) - \delta_i = 0$$

$$\frac{\partial R^G_{reject}(\delta_i)}{\partial \mu_{reject}(\delta_i)} = -\frac{1}{2}[\underline{y} + \lambda x_{reject}(\delta_i) + \alpha\theta x_{reject}(\delta_i) + \alpha\sigma\mu_{reject}(\delta_i) - \pi^e - y_n]2\alpha\sigma = 0$$

According to these, $y_{reject}(\delta_i) = y_n$ that is the government eliminates entire output gap (if possible) when it rejects participation. If we do not put an upper limit on μ_i, the government will eliminate all output gap with only monetary expansion (and make zero fiscal expenditure) since, unlike fiscal expansion, it is not associated with any cost. To avoid this, we again assume $\mu_i \in [\mu_{min}, \mu_{max}]$ where $\mu_{max} < y_n + \pi^e - \underline{y} \equiv K$ which ensures that the government cannot eliminate entire output gap only using monetary expansion. Thus, $\mu_{reject}(\delta_i) = \mu_{max} \forall \delta_i \in \{\underline{\delta}, \bar{\delta}\}$. Using this gives the following:

$$x_{reject}(\delta_i) = \frac{K - \alpha\sigma\mu_{max}}{\lambda + \alpha\theta} - \frac{\delta_i}{(\lambda + \alpha\theta)^2}$$

Define $\Delta x_{reject} \equiv x_{reject}(\bar{\delta}) - x_{reject}(\underline{\delta})$.

$$\Delta x_{reject} = \frac{K - \alpha\sigma\mu_{max}}{\lambda + \alpha\theta} - \frac{\bar{\delta}}{(\lambda + \alpha\theta)^2} - \frac{K - \alpha\sigma\mu_{max}}{\lambda + \alpha\theta} + \frac{\underline{\delta}}{(\lambda + \alpha\theta)^2} = -\frac{(\bar{\delta} - \underline{\delta})}{(\lambda + \alpha\theta)^2} < 0$$

One can also obtain the following:

$$y_{reject}(\delta_i) = y_n - \frac{\delta_i}{\lambda + \alpha\theta}$$

which implies $y_{reject}(\bar{\delta}) < y_{reject}(\underline{\delta})$ since $\bar{\delta} > \underline{\delta}$. Now look at $R^G_{reject}(\delta_i)$:

$$R^G_{reject}(\delta_i) = -\frac{1}{2}\left[-K + K - \alpha\sigma\mu_{max} - \frac{\delta_i}{(\lambda + \alpha\theta)} + \alpha\sigma\mu\right]^2 - \delta_i\left[\frac{K - \alpha\sigma\mu_{max}}{\lambda + \alpha\sigma} - \frac{\delta_i}{(\lambda + \alpha\theta)^2}\right]$$

Rearranging this expression results in:

$$R^G_{reject}(\delta_i) = \frac{1}{2}\left[\frac{\delta_i}{\lambda + \alpha\theta}\right]^2 - \frac{\delta_i(K - \alpha\sigma\mu_{max})}{(\lambda + \alpha\theta)^2}$$

After calculating the return that each government type would get in the case of rejecting the central bank's offer, now inspect the government behavior when it accepts the central bank's monetary policy offer. First, define $R^G(\delta_i, \delta_i)$ as the return from truth telling (acting as its own type δ_i) for government with type δ_i . Define $c(\delta_i)$ as the contract that is offered by the central bank with the expectation that it would be accepted by the government with type δ_i . Each contract is a couple of monetary and fiscal policies, i.e. $c(\delta_i) = \{\mu(\delta_i), x(\delta_i)\}$ - the central bank offers $\mu(\delta_i)$ to the government with type δ_i and expects it to spend $x(\delta_i)$. Then $R^G(\delta_i, \delta_i)$ can be written in the following way:

$$R^G(\delta_i, \delta_i) = -\frac{1}{2}[-K + (\lambda + \alpha\theta)x_i + \alpha\sigma\mu_i]^2 - \delta_i x_i$$

As in the case of complete information, treat μ_i as a constant function and let x_i be a function of μ_i . The first order condition with respect to x_i in this case turns out to be:

$$\frac{\partial R^G(\delta_i, \delta_i)}{\partial x_i} : -[-K + (\lambda + \alpha\theta)x_i + \alpha\sigma\mu_i](\lambda + \alpha\theta) - \delta_i = 0$$

Rearranging this equation results in:

$$x_i = \frac{K - \alpha\sigma\mu_i}{\lambda + \alpha\theta} - \frac{\delta_i}{(\lambda + \alpha\theta)^2}$$

Now the central bank’s ability to enforce truth telling on the government’s part can be studied. The incentive compatibility constraints for both government types are as follows:

$$R^G(\underline{\delta},\underline{\delta}) \geq R^G(\bar{\delta},\underline{\delta})$$

$$R^G(\bar{\delta},\bar{\delta}) \geq R^G(\underline{\delta},\bar{\delta})$$

The incentive compatibility constraint for a government of type δ_i suggests that the return from telling the truth should be equal to or higher than the return from lying and acting as type δ_j where $\delta_i \neq \delta_j$, that is $R^G(\delta_i,\delta_i) \geq R^G(\delta_j,\delta_i)$. Writing the incentive compatibility constraints in detail results in the following:

$$-\frac{1}{2}\left[-K+K-\alpha\sigma\underline{\mu}-\frac{\underline{\delta}}{(\lambda+\alpha\theta)}+\alpha\sigma\underline{\mu}\right]^2-\underline{\delta}\underline{x} \geq -\frac{1}{2}\left[-K+K-\alpha\sigma\bar{\mu}-\frac{\bar{\delta}}{(\lambda+\alpha\theta)}+\alpha\sigma\bar{\mu}\right]^2-\underline{\delta}\bar{x}$$

$$-\frac{1}{2}\left[-K+K-\alpha\sigma\bar{\mu}-\frac{\bar{\delta}}{(\lambda+\alpha\theta)}+\alpha\sigma\bar{\mu}\right]^2-\bar{\delta}\bar{x} \geq -\frac{1}{2}\left[-K+K-\alpha\sigma\underline{\mu}-\frac{\underline{\delta}}{(\lambda+\alpha\theta)}+\alpha\sigma\underline{\mu}\right]^2-\bar{\delta}\underline{x}$$

where $(\bar{\mu},\bar{x})$ is the monetary and fiscal policy in the contract offered by the central bank to the government type $\bar{\delta}$. Similarly $(\underline{\mu},\underline{x})$ corresponds to the pair of monetary and fiscal policies offered by the central bank to the government type $\underline{\delta}$. Rearranging the incentive compatibility constraints multiple times yields:

$$\frac{(\bar{\delta}-\underline{\delta})^2}{2(\lambda+\alpha\theta)} \geq \underline{\delta}\alpha\sigma(\bar{\mu}-\underline{\mu})$$

$$\frac{(\bar{\delta}-\underline{\delta})^2}{2(\lambda+\alpha\theta)} \geq \bar{\delta}\alpha\sigma(\underline{\mu}-\bar{\mu})$$

Given the monetary policies offered by the central bank to both government types, the participation constraints of the two government types can be written in the following way:

$$R^G(\underline{\delta},\underline{\delta}) \geq R^G_{reject}(\underline{\delta})$$

$$R^G(\bar{\delta},\bar{\delta}) \geq R^G_{reject}(\bar{\delta})$$

The participation constraints simply suggest that the return from accepting the central bank's offer conditional on truth telling should be equal to or higher than the return from rejecting the central bank's offer for both government types. Using the results from the previous analysis, the participation constraints can be written in detail:

$$-\frac{1}{2}[-\frac{\underline{\delta}}{(1+\theta)}]^2 - \underline{\delta}\underline{x} \geq -\frac{1}{2}[-K + K - \alpha\sigma\mu_{max} - \frac{\bar{\delta}}{(\lambda+\alpha\theta)} + \alpha\sigma\mu_{max}]^2 - \underline{\delta}\underline{x}_{reject} - F$$

$$-\frac{1}{2}[-\frac{\bar{\delta}}{(1+\theta)}]^2 - \bar{\delta}\bar{x} \geq -\frac{1}{2}[-K + K - \alpha\sigma\mu_{max} - \frac{\underline{\delta}}{(\lambda+\alpha\theta)} + \alpha\sigma\mu_{max}]^2 - \bar{\delta}\bar{x}_{reject} - F$$

Re-arranging the participation constraints results in:

$$\underline{\mu} \geq \mu_{max} - \frac{F(\lambda+\alpha\theta)}{\underline{\delta}\alpha\sigma}$$

$$\bar{\mu} \geq \mu_{max} - \frac{F(\lambda+\alpha\theta)}{\bar{\delta}\alpha\sigma}$$

Up until this point, the conditions required to ensure the government's participation and accept only the contract associated with its own type have been established.

Given these conditions describing the government's behavior, now the central bank's optimal monetary policy problem can be explored. The central bank solves the following maximization problem:

$$
\begin{aligned}
\max_{\underline{\mu},\bar{\mu}} \mathbb{E}[R^{CB}(\underline{\mu},\bar{\mu},\underline{\delta},\bar{\delta},p)] \quad &= pR^{CB}(\underline{\mu},\underline{\delta})+(1-p)R^{CB}(\bar{\mu},\bar{\delta}) \\
\text{subject to} \quad & \frac{(\bar{\delta}-\underline{\delta})^2}{2(\lambda+\alpha\theta)} \geq \underline{\delta}\alpha\sigma(\bar{\mu}-\underline{\mu}) \\
& \frac{(\bar{\delta}-\underline{\delta})^2}{2(\lambda+\alpha\theta)} \geq \bar{\delta}\alpha\sigma(\underline{\mu}-\bar{\mu}) \\
& \underline{\mu} \geq \mu_{max} - \frac{F(\lambda+\alpha\theta)}{\underline{\delta}\alpha\sigma} \\
& \bar{\mu} \geq \mu_{max} - \frac{F(\lambda+\alpha\theta)}{\bar{\delta}\alpha\sigma} \\
& 0 \leq \underline{\mu},\bar{\mu} \leq \mu_{max} \\
& R^{CB}(\mu_i,\delta_i) = -\frac{1}{2}\pi(\mu_i,\delta_i)^2 = -\frac{1}{2}\Big[\frac{\theta K}{\lambda+\alpha\theta} - \frac{\theta\delta_i}{(\lambda+\alpha\theta)^2} + \frac{\lambda\sigma\mu_i}{\lambda+\alpha\theta}\Big]^2
\end{aligned}
$$

Now, to solve this problem first look at the return function of the central bank stated in the last row of the above problem. As it can be observed, it negatively depends both on $\underline{\mu}$ and $\bar{\mu}$ since given the government's optimal behavior, an increase in monetary expansion leads to higher inflation. Therefore, the central bank would want to offer as little monetary expansion as possible to each government type.

Now using the participation an incentive compatibility constraints, derive the intervals in which monetary policy takes place for each government type:

$$
\underbrace{\mu_{max} - \frac{F(\lambda+\alpha\theta)}{\underline{\delta}\alpha\sigma}}_{B} \leq \underline{\mu} \leq \underbrace{\frac{(\bar{\delta}-\underline{\delta})^2}{2\bar{\delta}\alpha\sigma(\lambda+\alpha\theta)}}_{D} + \bar{\mu}
$$

$$\underbrace{\mu_{max} - \frac{F(\lambda+\alpha\theta)}{\bar{\delta}\alpha\sigma}}_{C} \leq \bar{\mu} \leq \underbrace{\frac{(\bar{\delta}-\underline{\delta})^2}{2\underline{\delta}\alpha\sigma(\lambda+\alpha\theta)}}_{E} + \underline{\mu}$$

Since $\bar{\delta} > \underline{\delta}$ we have $C > B$ and $E > D$. Note that B and C are also decreasing functions of the fixed cost F. Suppose $F \in [F_{min}, F_{max}]$. Furthermore, assume that $B(F_{min}) \leq D$ - which ensures that there is always a monetary policy that satisfies the incentive compatibility and participation constraints of the government with type $\underline{\delta}$. As stated above, we know that the central bank wants to offer the smallest possible monetary expansion that satisfies the participation and incentive compatibility of each government. Since a smaller monetary policy, such as $\underline{\mu} = B$, can satisfy the participation constraint of the government with type $\underline{\delta}$, and also $\underline{\mu}$ limits $\bar{\mu}$ from above, the central bank would indeed set $\underline{\mu}^{\star} = B(F)$.

Now subtract B from C to obtain the following:

$$C(F) - B(F) = \frac{F(\lambda+\alpha\theta)}{\alpha\sigma}[\frac{\bar{\delta}-\underline{\delta}}{\bar{\delta}\underline{\delta}}]$$

After that, rewrite the expression combining the incentive and participation constraints of the type $\bar{\delta}$ by adding and subtracting $B(F)$ from both sides and also using that $\underline{\mu}^{\star} = B(F)$ in the following way:

$$C(F) - B(F) + B(F) \leq \bar{\mu} \leq E + B(F)$$

Re-arranging this inequality yields:

$$\frac{F(\lambda+\alpha\theta)}{\alpha\sigma}\left[\frac{\bar{\delta}-\underline{\delta}}{\bar{\delta}\underline{\delta}}\right]+B(F)\leq\bar{\mu}\leq E+B(F)$$

Now first assume that $C(F_{min})-B(F_{min})<E$. Then, if $F_{\max}$ is large enough, from the mean value theorem it can be concluded that $\exists\tilde{F}$ such that $C(\tilde{F})-B(\tilde{F})=E$. At $F=\tilde{F}$ we have:

$$\frac{\tilde{F}(\lambda+\alpha\theta)}{\alpha\sigma}\left[\frac{\bar{\delta}-\underline{\delta}}{\bar{\delta}\underline{\delta}}\right]=\frac{(\bar{\delta}-\underline{\delta})^2}{2\underline{\delta}\alpha\sigma(\lambda+\alpha\theta)}$$

Simplifying this equation results in:

$$\tilde{F}=\frac{(\bar{\delta}-\underline{\delta})\bar{\delta}}{2(\lambda+\alpha\theta)^2}$$

Therefore:

$$C(F)\begin{cases}\leq E+B(F) \text{ if } F\in[F_{min},\tilde{F}]\\ \geq E+B(F) \text{ if } F\in[\tilde{F},F_{max}]\end{cases}$$

Thus, the fixed cost F must be in the range $[F_{min},\tilde{F}]$ so that the central bank can offer a monetary policy that can both satisfy incentive compatibility and participation constraints of the government with type $\bar{\delta}$. If we regard $\bar{\delta}-\underline{\delta}$ as the extent of informational asymmetry between the government and the central bank, this result means that the range of institutional quality (measured with the degree of central bank independence – which corresponds to the parameter F in this model) is actually endogenously related to the extent of this informational asymmetry between the two agents. If $F > \tilde{F}$, i.e. if the central bank is more independent than the critical degree that is endogenously determined by the informational asymmetry, then it will not be able to act independently in practice. Because in this case with probability $1-p$ the central bank will encounter the government type $\overline{\delta}$ for which there does not exist a monetary policy that satisfies both incentive and participation constraints of this government type. In this case, the government $\overline{\delta}$ will actually decline the contract associated with its type as $F > \tilde{F}$ makes the monetary policy $\overline{\mu}$ too low to ensure participation.

Now study the case where $F = \tilde{F}$, that is assume that $C - B = E$. Re-writing the incentive and participation constraints of the government type $\overline{\delta}$ now results in:

$$B + E \leq \overline{\mu}^{\star} \leq E + \underline{\mu}^{\star}$$

Use $\underline{\mu}^{\star} = B$:

$$B + E \leq \overline{\mu}^{\star} \leq E + B$$

Therefore $\overline{\mu}^{\star} = E + B$. The optimal solution to the central bank's problem then is the following pair of monetary policies:

$$\underline{\mu}^{\star} = \mu_{max} - \frac{\tilde{F}(\lambda + \alpha\theta)}{\underline{\delta}\alpha\sigma}$$

$$\bar{\mu}^{\star} = \frac{(\bar{\delta} - \underline{\delta})^2}{2\underline{\delta}\alpha\sigma(\lambda + \alpha\theta)} + \mu_{max} - \frac{\tilde{F}(\lambda + \alpha\theta)}{\underline{\delta}\alpha\sigma}$$

As these results indicate, in the incomplete information case, the government with high marginal fiscal cost benefits from informational asymmetry and obtains a positive information rent in the form of:

$$\underbrace{\bar{\mu}^{\star}(\tilde{F}) - \bar{\mu}_{complete}(\tilde{F})}_{\text{information rent}} = \frac{(\bar{\delta} - \underline{\delta})}{\underline{\delta}}\Big[\frac{(\bar{\delta} - \underline{\delta})}{2(\lambda + \alpha\theta)} - \frac{\tilde{F}(\lambda + \alpha\theta)}{\bar{\delta}\alpha\sigma}\Big]$$

According to this, information rent of the government with high fiscal cost positively depends on the magnitude of informational asymmetry, and negatively on the fixed cost of circumventing the central bank, i.e. $\tilde{F}$. On the other hand, the government with low marginal fiscal cost does not benefit from informational asymmetry; therefore its information rent is zero.

$$\underline{\mu}^{\star}(\tilde{F}) = \underline{\mu}_{complete}(\tilde{F})$$

Because of the informational asymmetry, the $\bar{\delta}$ type government's fiscal expansion also differs from its complete information level:

$$\bar{x}^{\star} - \bar{x}_{complete} = -\frac{\alpha\sigma(\bar{\mu}^{\star} - \bar{\mu}_{complete})}{\lambda + \alpha\theta}$$

These results show that the deviation of fiscal expansion from its complete information level is somehow different compared to the deviation of monetary expansion because of the parameter because of the term $(\alpha\sigma)/(\lambda+\alpha\theta)$.

Now one can find what happens to expected inflation due to changes in the degree of central bank independence. The expected inflation when $F = F_{\min}$ and $F = \tilde{F}$ can be written as:

$$\mathbb{E}\pi(F_{\min}) = p[\theta\underline{x}^*(F_{\min}) + \sigma\underline{\mu}^*(F_{\min})] + (1-p)[\theta\overline{x}^*(F_{\min}) + \sigma\overline{\mu}^*(F_{\min})]$$

$$\mathbb{E}\pi(\tilde{F}) = p[\theta\underline{x}^*(\tilde{F}) + \sigma\underline{\mu}^*(\tilde{F})] + (1-p)[\theta\overline{x}^*(\tilde{F}) + \sigma\overline{\mu}^*(\tilde{F})]$$

Subtracting the expressions above from each other clearly illustrates the seesaw and delegation effects:

$$\begin{aligned}\mathbb{E}\pi(F_{\min}) - \mathbb{E}\pi(\tilde{F}) = \; & \underbrace{\theta\{p[\underline{x}^*(F_{\min}) - \underline{x}^*(\tilde{F})] + (1-p)[\overline{x}^*(F_{\min}) - \overline{x}^*(\tilde{F})]\}}_{\text{Seesaw Effect (SE)}} \\ & \underbrace{\sigma\{p[\underline{\mu}^*(F_{\min}) - \underline{\mu}^*(\tilde{F})] + (1-p)[\overline{\mu}^*(F_{\min}) - \overline{\mu}^*(\tilde{F})]\}}_{\text{Delegation Effect (DE)}}\end{aligned}$$

The seesaw effect can be re-written in the following manner:

$$\begin{aligned}SE = \; & \theta p\Big\{\frac{K - \alpha\sigma\underline{\mu}^*(F_{\min})}{\lambda+\alpha\theta} - \frac{\underline{\delta}}{(\lambda+\alpha\theta)^2} - \Big[\frac{K - \alpha\sigma\underline{\mu}^*(\tilde{F})}{\lambda+\alpha\theta} - \frac{\underline{\delta}}{(\lambda+\alpha\theta)^2}\Big]\Big\} \\ & +\theta(1-p)\Big\{\frac{K - \alpha\sigma\overline{\mu}^*(F_{\min})}{\lambda+\alpha\theta} - \frac{\overline{\delta}}{(\lambda+\alpha\theta)^2} - \Big[\frac{K - \alpha\sigma\overline{\mu}^*(\tilde{F})}{\lambda+\alpha\theta} - \frac{\overline{\delta}}{(\lambda+\alpha\theta)^2}\Big]\Big\}\end{aligned}$$

\

Re-arranging this expression results in:

$$SE = -\frac{\theta\alpha\sigma}{\lambda+\alpha\theta}\underbrace{\left\{p[\underline{\mu}^*(F_{\min}) - \underline{\mu}^*(\tilde{F})] + (1-p)[\bar{\mu}^*(F_{\min}) - \bar{\mu}^*(\tilde{F})]\right\}}_{\frac{DE}{\sigma}}$$

Therefore:

$$SE = -\frac{\alpha\theta}{\lambda+\alpha\theta}DE$$

Which implies that $|SE| \leq |DE|$ regardless of the magnitude of the informational asymmetry, i.e. $(\bar{\delta} - \underline{\delta})$ while the magnitudes of both SE and DE depend on $(\bar{\delta} - \underline{\delta})$. If $\lambda = 0$, that is there is no direct effect of fiscal policy on output aside from its indirect effect via creating inflation, the seesaw effect and delegation effect always dominate each other and in this special case there is no correlation between expected inflation and institutional quality (measured here with F). In other cases where, the delegation effect dominates the seesaw effect and higher institutional quality results in lower expected inflation.

However, more importantly, the informational asymmetry $(\bar{\delta} - \underline{\delta})$ has a positive effect on the level of the specific level of fixed cost $\tilde{F}$. If fixed cost in practice F is larger than this hypothetical level $\tilde{F}$, then the central bank cannot enforce both incentive compatibility and participation of the government with $\bar{\delta}$. The central bank would want to act independently – that is the central bank would want to enforce both governments to participate and accept the offer associated with their own type – and under informational asymmetry between the central bank and the government this is only possible if $F < \tilde{F}$ where $\tilde{F}$ is positively related to

$(\bar{\delta} - \underline{\delta})$. If $F \in (\tilde{F}, F_{\max})$, then the government with high marginal fiscal cost will lie about its type and only the contract offered by the central bank targeted at the type with low fiscal cost will be accepted by both government types. Therefore, the expected inflation will not depend F anymore, and both the delegation and the seesaw effects will be zero. Consequently, the relationship between inflation and central bank independence will be zero in these cases.

2.4 Conclusion

In this study, the relationship between the degree of central bank independence and inflation is studied both empirically and theoretically. The empirical findings obtained via panel regressions provide evidence supporting the existence of a potentially non-negative relationship between central bank independence and inflation in a large set of countries. The empirical analysis also indicates two distinct effects of a change in the degree of central bank independence on inflation: a direct and negative effect (the delegation effect), and a positive and indirect effect through the worsening of fiscal balances (the seesaw effect). The two distinct and opposite effects seem to be balancing each other so that the results of the empirical analysis allows one to reject the negativity of the relationship between inflation and central bank independence.

In order to account for this empirical observation, a theoretical model involving a policy game taking place between the government and the central bank is modeled. While the central bank is independent in its decision making, if the government pays an exogenous cost of circumventing the central bank's authority on the determination of the monetary policy, the government can choose its desired monetary and fiscal policies on its own.

The model in the perfect information case generates the expected (but not empirically supported) negative relationship between inflation and the degree of central bank independence. The two distinct effects are already at play: if the central bank becomes more independent then it allows a relatively lower level of monetary expansion (the delegation effect), but this in turn results in a higher reliance on fiscal expansion on the government's side since for the government monetary and fiscal policies are substitutes to eliminate the output gap. However, the increase in fiscal expansion is lower than the reduction in the monetary expansion – which results in a lower expected inflation level.

However, when an informational asymmetry regarding the government's marginal cost of fiscal expansion is introduced, the model can now generate a zero correlation between expected inflation and a change in the degree of central bank independence under specific conditions. The extent of the informational asymmetry endogenously determines the range of the cost to be paid by the government in order to circumvent the central bank's authority. If the level of this cost falls outside the endogenously determined interval, that is if the institutional quality is not in alignment with the informational asymmetry, then the model generates a zero correlation between inflation and central bank independence. The reason behind this result is the fact that now the central bank is unable to offer a policy which enforces the government with high fiscal cost to tell the truth and accept the contract aimed at its own type.

CHAPTER 3

DYNAMICS OF INTERGENERATIONAL EDUCATIONAL MOBILITY ACROSS EUROPE

3.1 Introduction

The focus of modern macroeconomics has expanded beyond the dynamics of only economic aggregates into the evolution of the distribution of economic variables over the recent decades[15]. Concerns over the distribution of fundamental economic welfare variables, such as earnings, income and wealth have motivated a growing body of studies to explore cross-sectional and time-series behaviors of economic inequalities, along with their determinants and consequences. Of the underlying sources of economic inequalities, intergenerational persistence of earnings, income and wealth have been attracting particular attention, mostly due to their role in influencing how well-functioning an economy is through the equality of opportunity and prospect of social mobility channels[16]. While earnings, income and wealth persistence across generations have been studied quite extensively, rigorous attempts to investigate intergenerational educational persistence, prospects of upward and risks of downward educational mobility across countries have been limited both in number and in content. Further, these attempts have hardly surpassed documenting and comparing simple measures of average intergenerational educational persistence figures at the country level using basic and arguably problematic statistical methods.

[15] See Krueger et al. (2010), Heathcote et al. (2011) and Guvenen (2011) for discussions on the advances in the distributional macroeconomics literature.

[16] Krueger (2012) coins the term the ``Great Gatsby Curve" to refer to the positive cross-country relationship between income inequality and intergenerational earnings elasticity (to proxy for the inverse of social mobility), and highlights the importance of acknowledging this phenomenon in policy making.

Understanding the dynamics of educational attainment is critical for a number of reasons, but in particular because i) education is arguably the most pivotal determinant in accumulating human capital and as, especially in its later stages, education is decisive in affecting labor earnings, ii) educational attainment correlates highly with income and wealth accumulation, thereby preserving indirect intergenerational impacts[17]. Accordingly, in order to understand both the de facto prospects of social mobility and the evolution of welfare variables in an economy, it is essential to understand patterns in educational attainment across generations, as well.

In this paper, the evolution of intergenerational educational mobility across Europe is investigated in both country and regional level using data from the first seven waves of the European Social Survey for 34 countries and 46 cohorts (born between 1940-1985). First, intergenerational persistence of education is shown to have evolved differently across four main European regions (namely Mediterranean countries, Post-Socialist and Slavic countries, Nordic countries and the rest of Europe), driven both by changes in the distributions of family types (with respect to the maximum parental education) and in intergenerational educational mobility dynamics observed in each family type. In addition to the country and regional heterogeneity observed in aggregate mobility variables, intergenerational mobility figures are found to display substantial heterogeneity among different parental education groups, genders and parental couple compositions. Finally, within-cohort educational inequality is measured by calculating educational Gini coefficients for each country and cohort in the dataset, educational inequality patterns across

[17] See Díaz-Giménez et al. (2011) for a recent survey and discussion on the distribution of education, earnings, income, and wealth for the United States.

countries/regions are explored and the potential interaction between educational inequality and intergenerational persistence is investigated.

3.2 Literature review

Earlier studies in the literature of intergenerational transmission focused on the relationship between children and their parents' lifetime incomes. Becker and Tomes (1979) and Loury (1980) modelled intergenerational transmission of lifetime income by highlighting the role played by parents' investment into their children's education and biological transmission of innate abilities. In the light of these theoretical models, Corak and Heisz (1999), Jantti and Bjorklund (1997), Mazumder (2005), Lee and Solon (2009), Chetty et al. (2014) and Kopczuk et al. (2010) and many other empirical studies investigated the intergenerational relationship between parents' and children's lifetime incomes for different countries and cohorts born in various time periods.

Alongside the intergenerational transmission of income and earnings literature, another strand of literature that analyzed intergenerational persistence phenomenon in terms of educational attainment has also emerged. As described in Schneebaum et al. (2015) there are some methodological advantages of studying the relationship between children's and parents' educational attainment versus focusing on the relationship among their incomes. First, in the income persistence literature, generally, children's income at a year around his/her 30 year age is used as a proxy of his/her life-time earnings and the relationship between this income measure and parents' earnings at a year during children's adolescence years is used as a measure of parental life-time income. This practice actually provides a correlation among incomes in a specific year in an individual's and their parents' life. However, as Taber

(2001) and Gottschalk (1997) show that college premium in the US economy has been steadily positive and increasing over each new cohort, there is an empirically supported positive relationship between educational attainment and lifetime income. Secondly, most of the time parents' income information is obtained via children's reports and this may create measurement errors in parental income, whereas educational attainment of children and parents is easier to observe.

In the literature related to the intergenerational educational mobility, most notable recent studies are Hertz et al. (2007) and Schneebaum et al. (2015). Using data from resources such as World Bank Living Standards Measurement Survey, European Social Survey and International Adult Literacy Survey...etc., Hertz et al. (2007) measure the coefficient of intergenerational educational correlation for 42 countries covering the period 1927-1967. Schneebaum et al. (2015) calculates this coefficient for 20 European countries for the cohorts born in 1920-1985 using data from European Social Survey. Erola (2009) and Fessler et al. (2012) are recent studies that investigate this relationship using data for Finland and Austria, respectively. In Hertz et al. (2007) and Schneebaum et al. (2015), the intergenerational educational correlation coefficient is calculated via ordinary least squares by assuming that there is a linear relationship among parent's and children's education and defining educational attainment as "the years of schooling completed". This methodology implicitly assumes that an extra year of parental education towards primary school degree and college degree have the same impact on the years of schooling completed by the child. However, as Blanden (2013) states there is not any scientific study supporting the existence of a linear relationship between parents' and children's education. Moreover, using years of schooling as the measure of educational attainment results in the unequal treatment of two individuals who achieved the same educational attainment level with different years of schooling.

The studies listed above are only concerned with the measurement of the degree of intergenerational educational mobility. There does not exist any academic study that investigates the potential relationship among educational mobility and educational inequality or macroeconomic conditions. In the intergenerational income mobility literature, Mayer and Lopoo (2008) investigate how intergenerational income mobility is affected from public state expenditure and find that mobility is higher in states where public expenditure is also high. In addition, Corak (2013) has empirically shown that there is a positive cross-sectional correlation between income inequality and intergenerational persistence of income. In the educational mobility literature, only Blanden (2013) provides some cross-sectional correlations between educational mobility and various macroeconomic variables. Aside from the mobility literature, Dellas and Sakellaris (2003), Sakellaris and Spilimbergo (2000) and Taylor and Rampino (2014) investigate how educational decisions of individuals are affected from macroeconomic conditions.

3.3 Data

The main data source for this study is the European Social Survey (ESS) waves 1-7. Specifically, individuals who are born in the time period between 1940-1985 and were at least 25 years old at the time of survey are selected and individuals below the age 25 are excluded from the sample since they are very much likely no to have completed their education. These criteria yield a total number of 219,603 respondents from 34 European countries (Israel and Luxembourg which are part of the ESS are not included in this analysis). Table 5 displays the descriptive statistics for the dataset used in this study. Table 6 shows the list of countries and the ratio of respondents from each country.

Table 5. Descriptive Statistics – European Social Survey Waves 1-7

Variable	Mean	Std. Error	Minimum	Maximum	Obs.
Age	47.09	12.42	25	75	219491
Gender	0.53	0.49	0	1	219498
Years of schooling	12.72	3.98	0	56	217788
Respondent's education	2.06	0.74	1	3	219603
Father's education	1.73	0.8	1	3	219603
Mother's education	1.56	0.74	1	3	219603

Educational attainment levels of individuals and parents are divided into three categories: low education (less than upper secondary education, including ISCED 0-1-2 categories), medium education (upper secondary education and post-secondary education, ISCED 3-4) and high education (tertiary education, ISCED 5-6). First four waves of the ESS actually allow educational attainment to be categorized in six main ISCED categories, and last three waves even permit a more detailed categorization (using subcategories of the main ISCED classification). However, a three level education categorization is adopted here for two reasons: first, using the default education categorization provided in the ESS results in statistically insignificant estimates in some countries and cohorts for which there are relatively small numbers of observations. Secondly, and more importantly, small transitions between the main ISCED categories (such as a one level upward movement from lower secondary education to upper secondary education, i.e. from ISCED 2 to 3) may not be meaningful in terms of mobility. Therefore, we define education categories in a way ensuring that each education category differs from others in terms of content, potential labor market outcomes...etc.

Table 6. Number of Observations by Country

Country	Country#	Observations	Share
Albania	1	811	0.004
Austria	2	6158	0.027
Belgium	3	8549	0.037
Bulgaria	4	6214	0.027
Switzerland	5	8858	0.039
Cyprus	6	3252	0.014
Czech Republic	7	9621	0.042
Germany	8	14417	0.063
Denmark	9	7819	0.034
Estonia	10	7651	0.034
Spain	11	8034	0.035
Finland	12	9889	0.043
France	13	9348	0.041
United Kingdom	14	9265	0.041
Greece	15	6658	0.029
Croatia	16	2210	0.010
Hungary	17	6907	0.030
Ireland	18	11247	0.049
Iceland	19	923	0.004
Italy	20	1521	0.007
Lithuania	21	2668	0.012
Latvia	22	1403	0.006
The Netherlands	23	10002	0.044
Norway	24	8491	0.037
Poland	25	8328	0.037
Portugal	26	8096	0.035
Romania	27	1559	0.007
Russia	28	6948	0.030
Sweden	29	8829	0.039
Slovenia	30	6566	0.029
Slovakia	31	6517	0.029
Turkey	32	3069	0.013
Ukraine	33	6827	0.030
Kosovo	34	948	0.004

3.4 Methodology

The main methodology that is employed in this paper involves the usage of logistic regressions where the dependent variable is a child's educational attainment and the main explanatory variable is the maximum education level that is attained by the parents of the child[18]. Furthermore, I define educational attainment as "the highest degree of education achieved" due to the methodological concerns discussed before. Using this definition, I assume that individual i's, born in year t , educational attainment E_{it} depends on a latent variable called E_{it}^* which is defined in the following way:

$$E_{it}^* = \beta_t P_{it} + \epsilon_{it}$$

where P_{it} is the parental education of individual i[19]. Depending on the value of E_{it}^*, educational outcome of descendant i takes the value of one (for low-education), two (medium-education) or three (high-education). Therefore, the educational outcome of individual i is described by the following piecewise function:

$$E_{it} = \begin{cases} 1 & \text{if} E_{it}^* \leq \theta_{1t} \\ 2 & \text{if} \theta_{1t} < E_{it}^* \leq \theta_{2t} \\ 3 & \text{if} \theta_{2t} < E_{it}^* \leq \theta_{3t} \end{cases}$$

[18] Unlike the methodology adopted in Hertz et al. (2007) and Schneebaum et al. (2015), we do not assume that the relationship between parental education and children's education is linear. Moreover, in contrast to these studies, we do not measure educational attainment with years of schooling completed.

[19] While using parental education as a control variable, following earlier literature on education we use 4 different specifications: the maximum education attainment of the parents, the average education of the parents, only mother's education and only father's education. Further, for the former two groups, we use combinational parental couple dummy variables to capture the impacts of differences in the couple formation on the descendants' education. Some of the earlier studies in the literature add flow variables, such as income, place of residence or age for control purposes. This way of specification is problematic for a number of reasons, including creating econometric endogeneity problems, and the fact that the educational choices of the descendant may depend on life-time earnings, and not just on contemporaneous income, or current place of residence. Thus, we rely only on actual stock variables, i.e. educational attainment of the parents (along with their gender structure) in our calculations when estimating intergenerational mobility figures.

Accordingly, the probability of a child's educational attainment being k can be described in the following way:

$$Pr(E_{it} = k \mid P_{it}) = Pr(\theta_{(k-1)t} < E_{it}^{*} \leq \theta_{kt}) = Pr(\theta_{(k-1)t} - \beta P_{it} < \epsilon_{it} \leq \theta_{kt} - \beta P_{it})$$

Conditional on the distribution of the error term, i.e. whether ε_{it} follows a normal or logistic distribution, I estimate the β vector by using the appropriate specification, such as logit regressions. Then, for the members of cohort t aggregate (or average) intergenerational educational persistence probability P_t, upward mobility probability U_t and downward mobility probability D_t are calculated using the following definitions:

$$P_t = \frac{\sum_{j=1}^{3} Pr_t(E = j \mid P = j) * N_t(P = j)}{\sum_{j=1}^{3} N_t(P = j)}$$

$$U_t = \frac{\sum_{j=1}^{2} Pr_t(E > j \mid P = j) * N_t(P = j)}{\sum_{j=1}^{2} N_t(P = j)}$$

$$D_t = \frac{\sum_{j=2}^{3} Pr_t(E < j \mid P = j) * N_t(P = j)}{\sum_{j=2}^{3} N_t(P = j)}$$

where $N_t(P = j)$ is the number of observations for whom parental education is equal to j in cohort t.

Since one of the aims of this study is to explore the relationship between educational inequality and intergenerational educational persistence, educational inequality is measured by calculating the Gini coefficient of education for each cohort using the approach described by Thomas et al. (2001). In order to accomplish this, first the unique values of years of education received by the members of cohort t is determined, then these values are ranked in increasing order. After that, the number of people corresponding to each years of education is found and the distribution of population with respect to years of education completed is created. Then, using this distribution the educational Lorenz curve of cohort t is constructed - from which the educational Gini coefficient is calculated.

3.5 Empirical results

3.5.1 Intergenerational educational mobility dynamics conditional on maximum parental education only

In this section, the regression results obtained with the first model are discussed, where the main explanatory variable is the maximum parental education in a family, and its variant where we estimate regional transition probabilities with country and cohort fixed effects. Regression outputs are displayed in Tables 7-10 (see Appendix B) for the groups of Mediterranean countries, Post-Socialist and Slavic countries, Nordic countries and Rest of European countries.

According to table 7, a child's educational attainment is positively correlated with the maximum education of her/his parents throughout the 1940-1985 period in the Mediterranean region. Furthermore each cohort fixed effect is positive (and nearly all of them are statistically significant), and the difference between two consecutive cohorts' effect seems to be increasing with each new year - suggesting that average educational attainment of each new cohort tends to increase over time. Portugal and Turkey seem to exhibit lower average educational attainment levels than the rest of the Mediterranean countries, as their country dummy variables are negative and significant. As Tables 8 and 10 show, similar observations with respect to the year fixed effects and the coefficient of the maximum parental education variable can be made for the Post-Socialist countries and the Rest of European countries groups as well.

According to table 9, there exists a positive and significant relationship between a child's educational attainment and her/his parents in the Nordic countries group as well. On the other hand, cohort fixed effects are not statistically significant for this group. Therefore, average educational attainment in Nordic countries seems to be relatively constant across cohorts compared to other country groups.

After looking at how descendants' educational attainment interact with their parents' education, aggregate mobility variables are calculated. Throughout Figures 5-7 the evolution of intergenerational educational persistence across countries between the two end points of our sample, the 1940-1944 period and the 1980-1985 period, is displayed. According to figure 5, children born in Mediterranean countries were the ones that experienced the highest degree of intergenerational educational persistence across Europe in 1940-1944 period (the probability of a randomly selected child to attain the same education level as her/his parents was around 0.75-0.89 in this group). On the other hand, socialist countries exhibited the lowest degree of persistence - which was between 0.34-0.38. Except for Finland, Nordic countries display low degrees of persistence, while Germanic Europe and Benelux countries had relatively medium levels of intergenerational educational persistence. For the

1980-1985 period, Figure 6 portrays a vastly different picture as it depicts a reversal for the ordering of countries with respect to their intergenerational persistence degrees. Now, most of the countries belonging to the post-socialist group tend to exhibit the highest levels of educational persistence observed in Europe (between 0.51-0.69). On the other hand, some Mediterranean countries (such as Portugal and Italy) show very moderate degrees of persistence compared to other European countries. Moreover, more heterogeneity is also observed in the Rest of Europe group, i.e. Ireland and the United Kingdom - who showed relatively higher degrees of educational persistence in 1940-1944 period - now exhibit lower degrees of persistence compared to other countries in this group such as Switzerland and Germany.

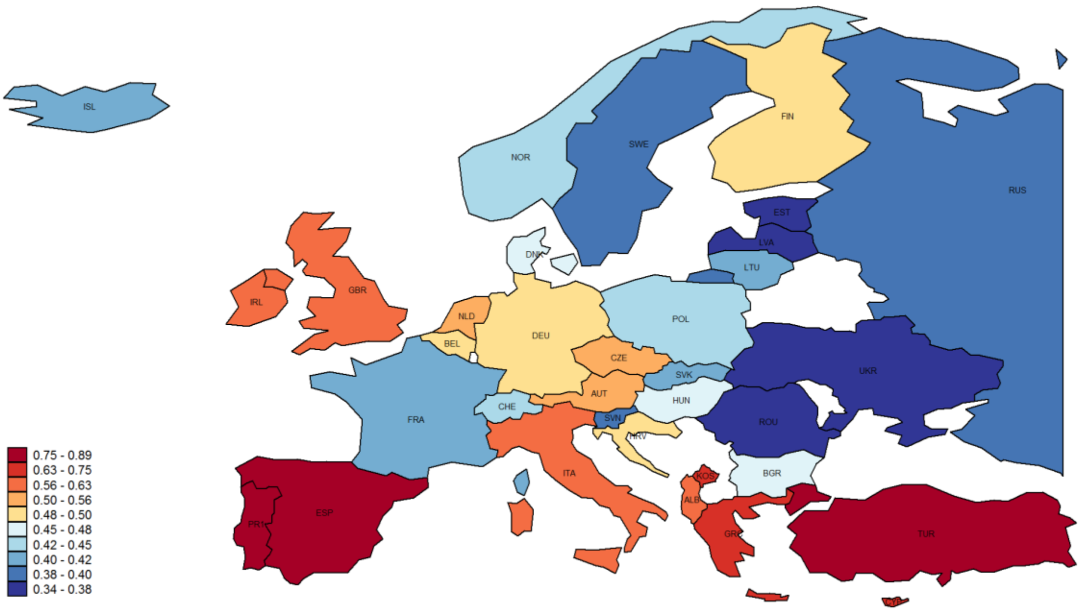

Fig. 5 Intergenerational educational persistence across Europe in 1940-1944

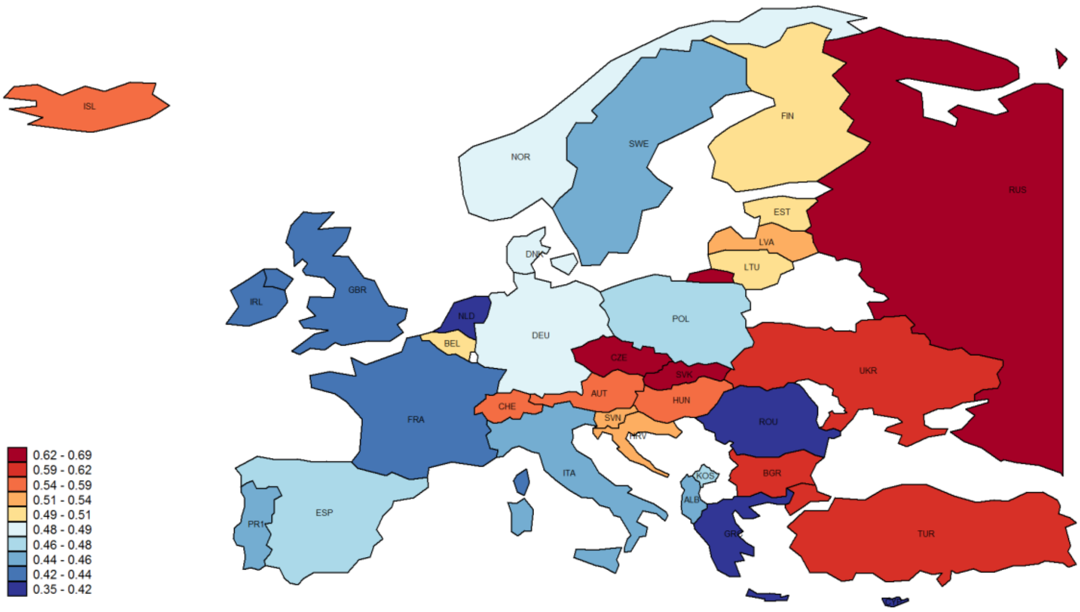

Fig. 6 Intergenerational educational persistence across Europe in 1980-1985

Figure 7 shows the degree at which intergenerational educational persistence changed between 1940-1944 and 1980-1985 periods across European countries. Largest decline is observed among Mediterranean countries (especially in Turkey, Portugal, Spain and Greece) while the largest increase is observed among Post-Socialist countries (especially in Russia, Ukraine, Slovakia, Estonia and Latvia). In Figure 8, the evolution patterns of intergenerational persistence probability across yearly cohorts are also provided in regional level. Figure 8 confirms that educational persistence probability has dramatically declined in the Mediterranean region and increased in the Post-Socialist country group over time. However, Figure 8 also presents a slightly U-shaped pattern for the evolution of intergenerational educational persistence in Nordic countries and the Rest of Europe.

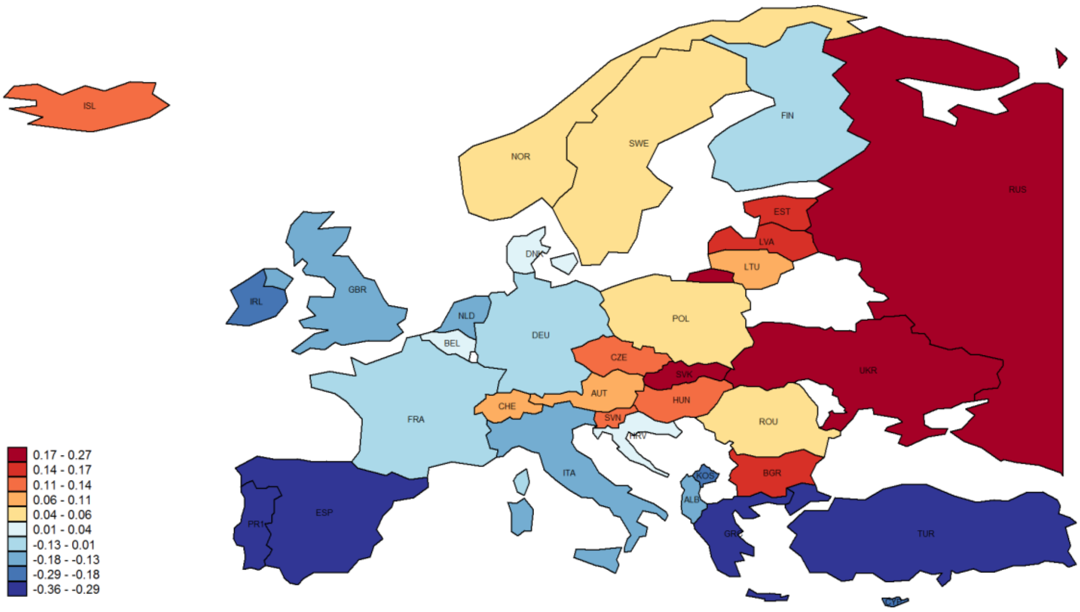

Fig. 7 Absolute change in intergenerational educational persistence across Europe in 1940-1985

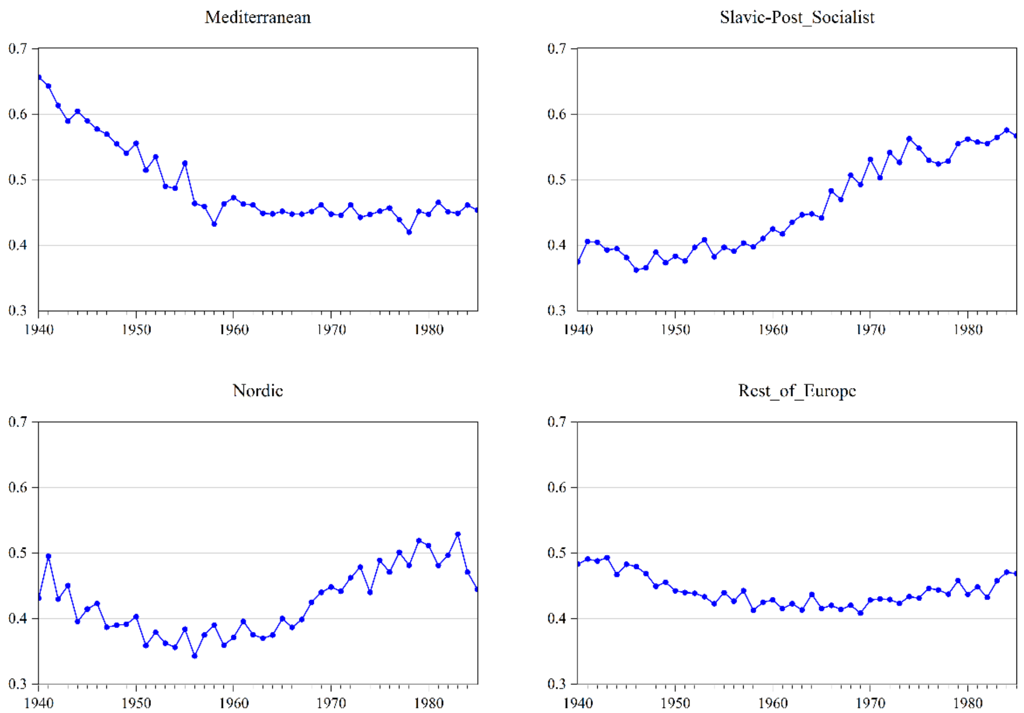

Fig. 8 Evolution of intergenerational educational persistence patterns across regions and cohorts

In order to understand the mechanism that lies behind this rank reversal observed across different regions of Europe, first it is necessary to identify the types of educational persistence most frequently observed in each region. By "types of persistence" following is meant: as educational attainment is categorized into three levels, i.e. low-medium-high, a child can experience intergenerational educational persistence in three ways - she can have low educated parents and attain a low education level (low-type persistence), she can have medium educated parents and medium educational attainment (medium-type persistence) or she may have highly educated parents and also attain a high education level (high-type persistence). Figures 9-14 show the rankings of European countries with respect to the frequency of each persistence type in 1940-1944 and 1980-1985 periods. According to figures 9 and 10, Mediterranean countries have been in the lead in terms of low-type persistence in both periods. Figures 11 and 12 show that the countries from Germanic Europe experienced the highest medium-type persistence, and figures 13-14 show that some Post-Socialist countries (such as Ukraine and Russia) and Nordic countries experienced the highest degrees of high-type persistence in Europe.

Therefore, in order for the cross-country persistence ranking to exhibit a reversal high-type persistence in Post-Socialist and Nordic countries and low-type persistence common in the Mediterranean region and the (Non-Germanic) Rest of Europe group must either move in opposite directions, or the high-type persistence in Post-Socialist and Nordic Europe must increase at a higher rate compared to the low-type persistence common in other parts of Europe.

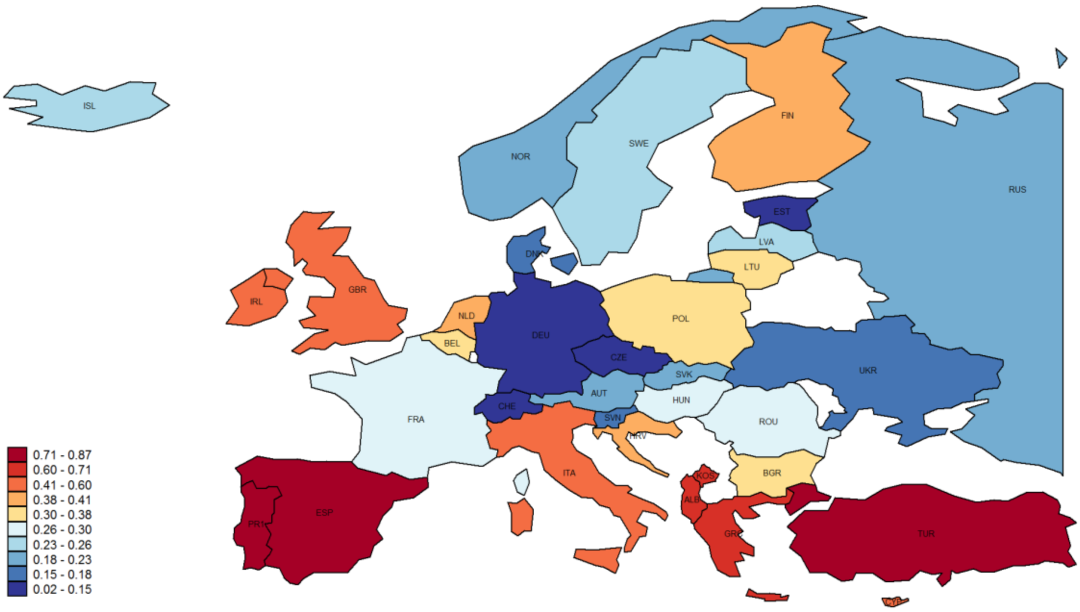

Fig. 9 Cross-country ranking of European countries according to the share of individuals that experienced low-type persistence in 1940-1944

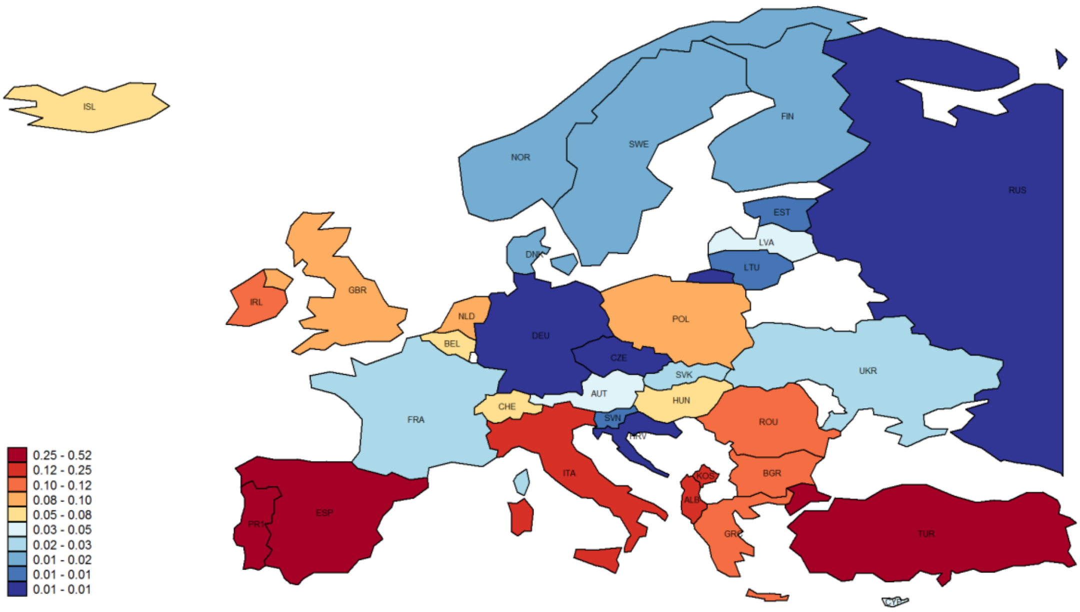

Fig. 10 Cross-country ranking of European countries according to the share of individuals that experienced low-type persistence in 1980-1985

From figures 9-10, it can be observed that low-type persistence in the Mediterranean Europe declines from 0.71-0.87 interval in 1940-1944 to 0.25-0.52 in 1980-1985. On the other hand, figures 13 and 14 show that high-type persistence in Post-Socialist and Nordic countries increases from 0.08-0.20 interval in 1940-1944 period to 0.24-0.61 in 1980-1985. These results indicate that the cross-country persistence ranking reversed because low-type persistence and high-type persistence evolved at opposite directions.

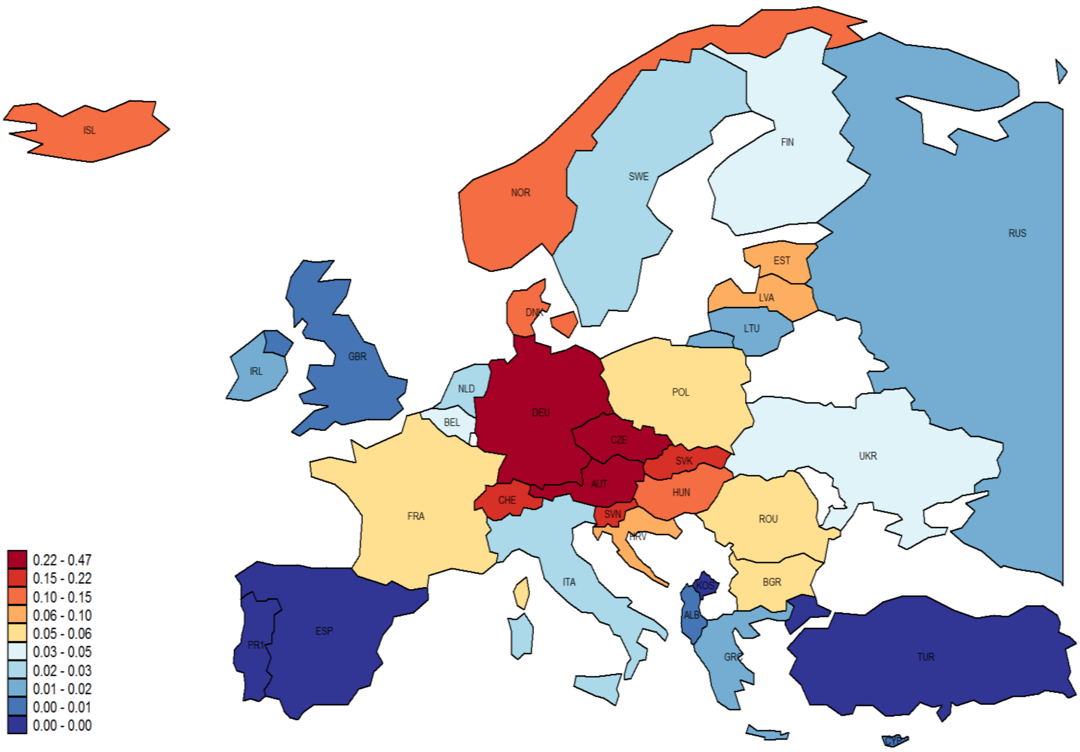

Fig. 11 Cross-country ranking of European countries according to the share of individuals that experienced medium-type persistence in 1940-1944

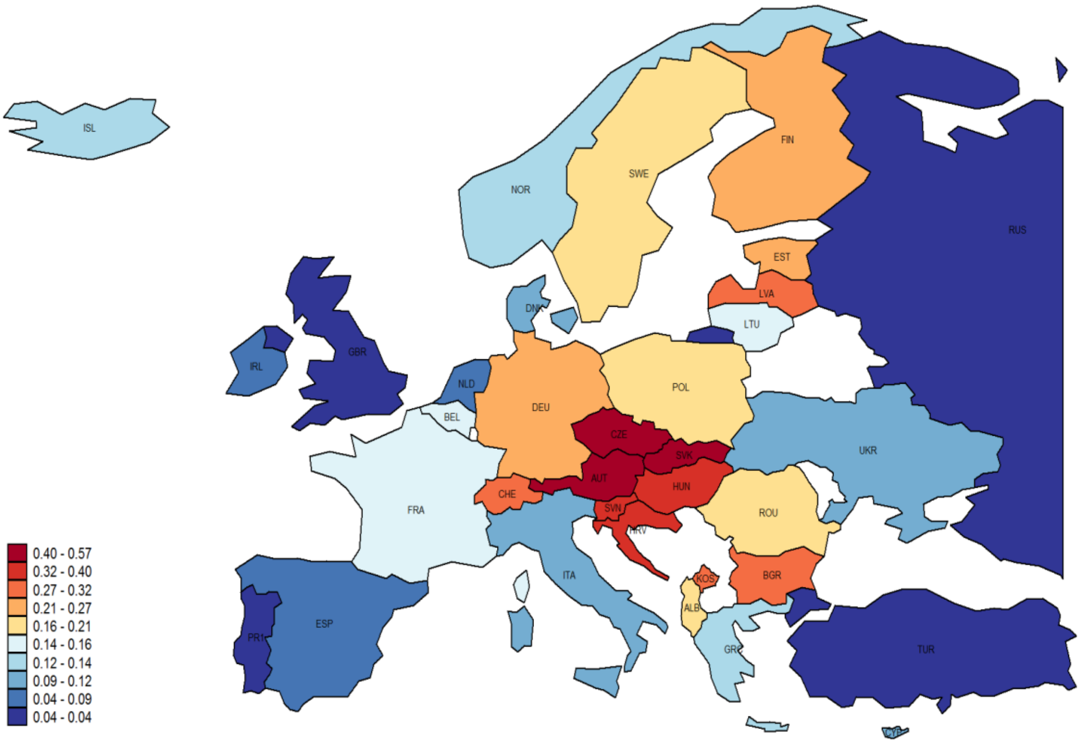

Fig. 12 Cross-country ranking of European countries according to the share of individuals that experienced medium-type persistence in 1980-1985

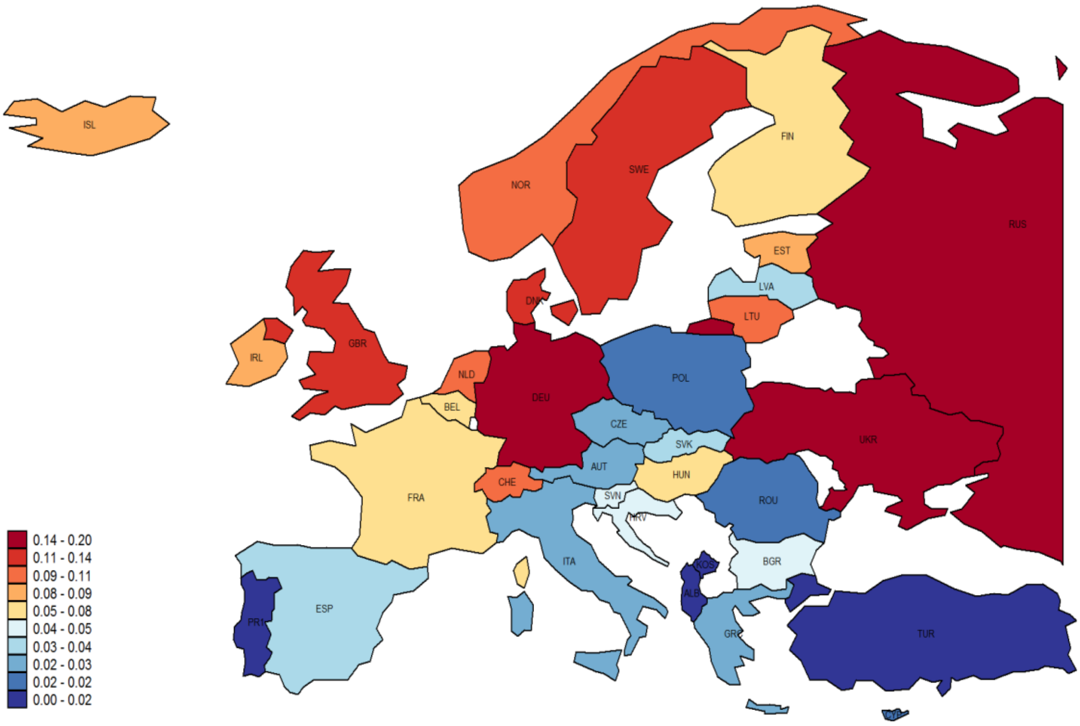

Fig. 13 Cross-country ranking of European countries according to the share of individuals that experienced high-type persistence in 1940-1944

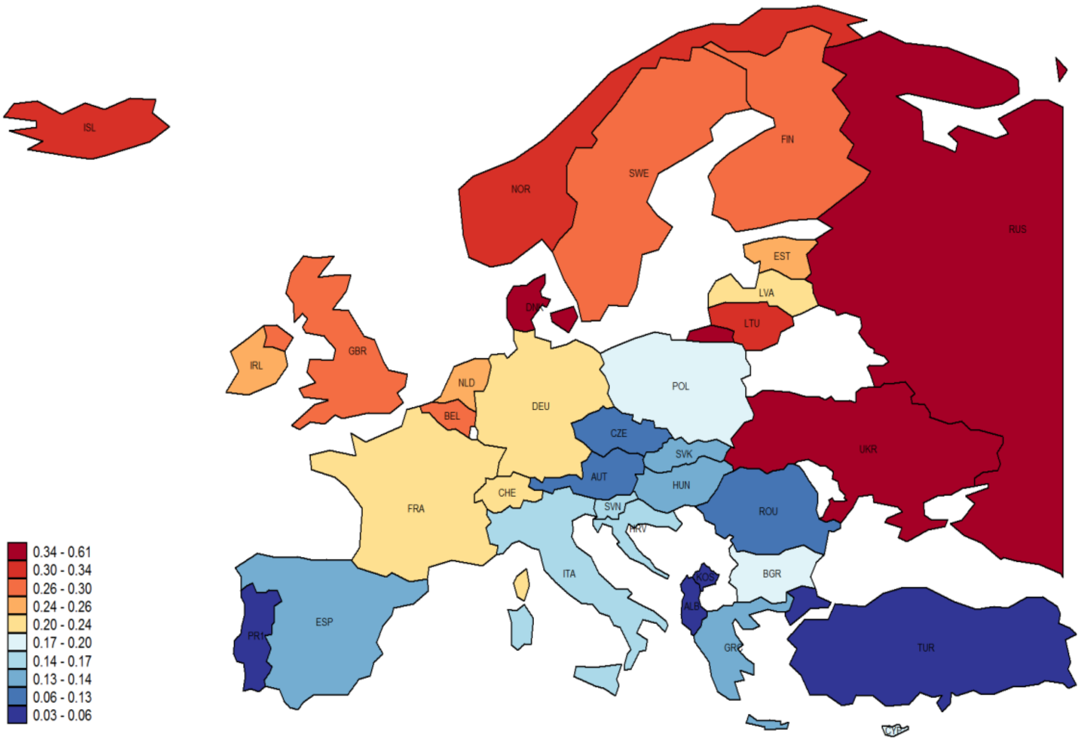

Fig. 14 Cross-country ranking of European countries according to the share of individuals that experienced high-type persistence in 1980-1985

In order for one persistence type to be more prevalent, at least one of the following has to take place: (i) the share of the family type associated with the persistence type must increase (holding the transition probabilities associated with each family type constant), (ii) the probability of attaining the education level associated with the persistence type must increase (holding the distribution of families across education levels constant) (iii) or the two kinds of changes must happen simultaneously. According to Figure 15, the share of families with low educated parents declined by 0.06-0.31 in Mediterranean countries, while persistence probability conditional on low education declined by 0.4 between 1940-1985 according to Figure 16.

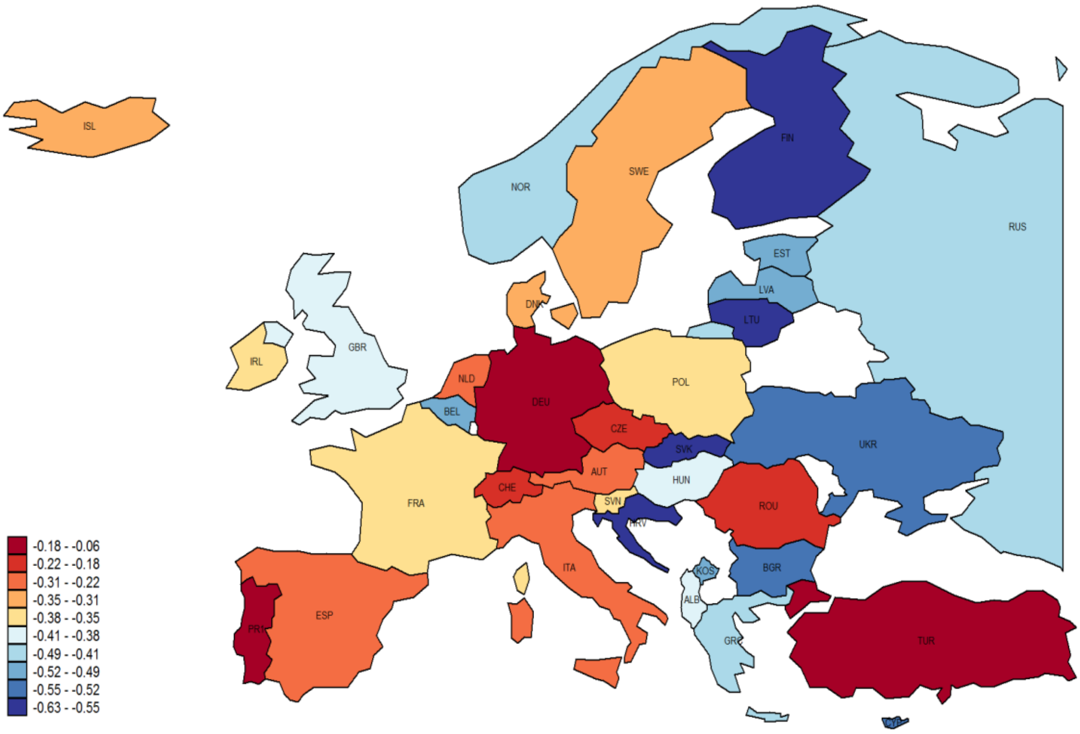

Fig. 15 Absolute change in the share of low educated parents across European countries between 1940-1985

On the other hand, share of high educated parents increased in the 0.18-0.36 interval in Post-Socialist and Nordic countries while according to Figure 20 probability of high education conditional on high parental education increased by 0.3 in Post-Socialist countries (and remained relatively constant in Nordic countries) in 1940-1985 period.

Thus, it can be concluded that both changes in the distribution of family types and changes in the intergenerational educational mobility dynamics conditional on the family type affected the evolution of aggregate intergenerational mobility variables across European countries.

Fig. 16 Evolution of transition probabilities conditional on low parental education across four main European regions between 1940-1985

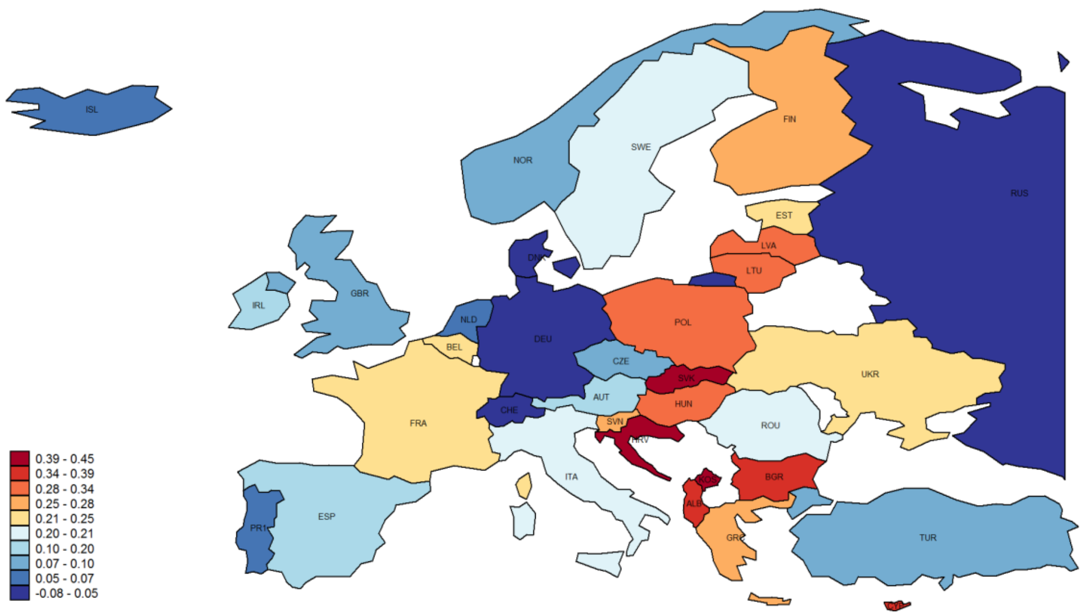

Fig. 17 Absolute change in the share of medium educated parents across European countries between 1940-1985

Fig. 18 Evolution of transition probabilities conditional on medium parental education across four main European regions between 1940-1985

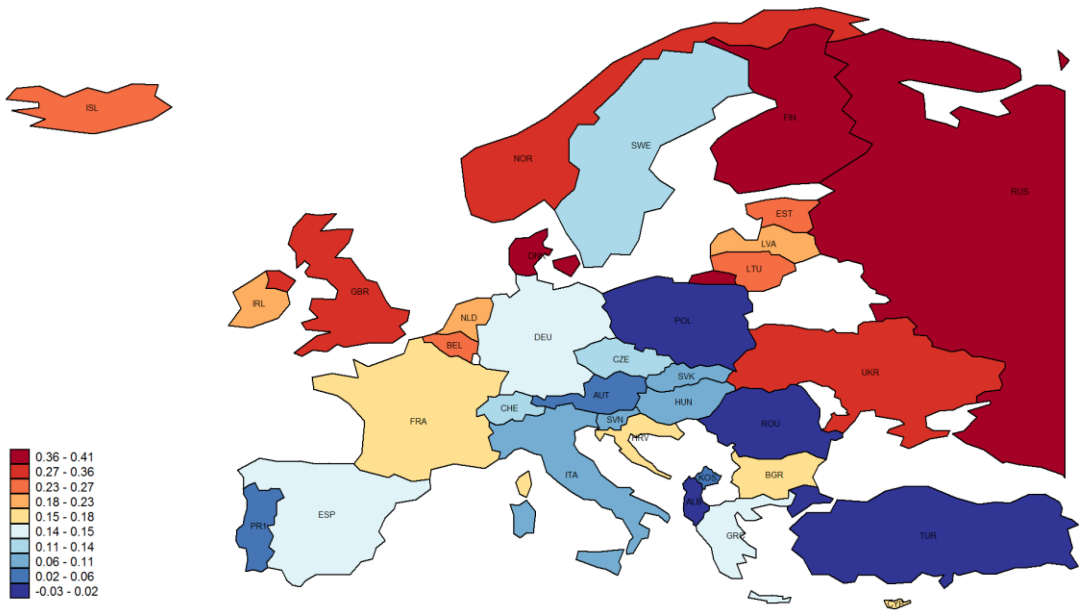

Fig. 19 Absolute change in the share of high-educated parents across European countries between 1940-1985

Fig. 20 Evolution of transition probabilities conditional on high parental education across four main European regions between 1940-1985

3.5.2 Educational equality of opportunity

The empirical methodology adopted in this study also allows the investigation of the evolution of educational equality of opportunity, which is defined as the probability of a child to attain high education conditional on low or medium parental education relative to the probability of having high education conditional on high parental education:

$$EO_t = \frac{Pr_t(E=3 \mid P \neq 3)}{Pr_t(E=3 \mid P=3)}$$

Figures 21 and 22 show the cross-sectional rankings of countries according to their degrees of educational equality of opportunity in 1940-1944 and 1980-1985 periods and the absolute change in equality of opportunity between the two time periods. According to figure 21, in the 1940-1944 period highest degrees of equality in educational opportunity were exhibited by Post-Socialist countries (especially in Poland, Romania, Russia and Estonia) while most unequal distribution of educational opportunity were observed among the Mediterranean country group (especially Turkey and Spain).

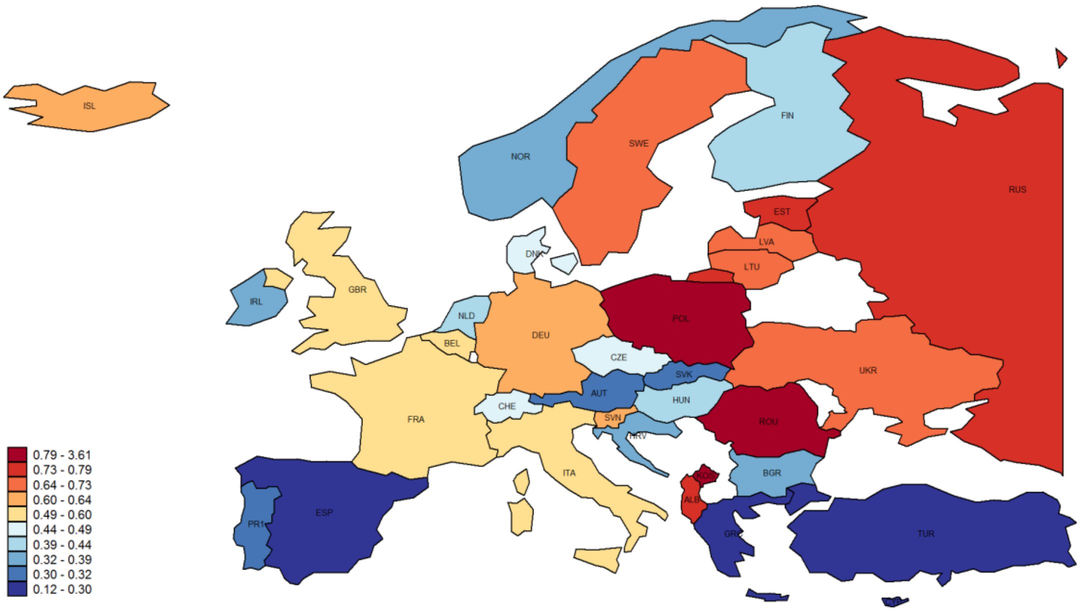

Fig. 21 Cross-country ranking of European countries according to the equality of educational opportunity in 1940-1944

On the other hand, it can be observed that the cross-country ranking of countries with respect to equality of opportunity has changed drastically in 1980-1985 period as now the highest degrees of equality in educational opportunities were exhibited mainly by countries in the Nordic and Rest of Europe (such as Germany, Netherlands, Great Britain) groups, together with Russia, Lithuania and France. Most substantial improvements seem to have happened in Mediterranean countries, Rest of Europe and Nordic countries (except for Sweden).

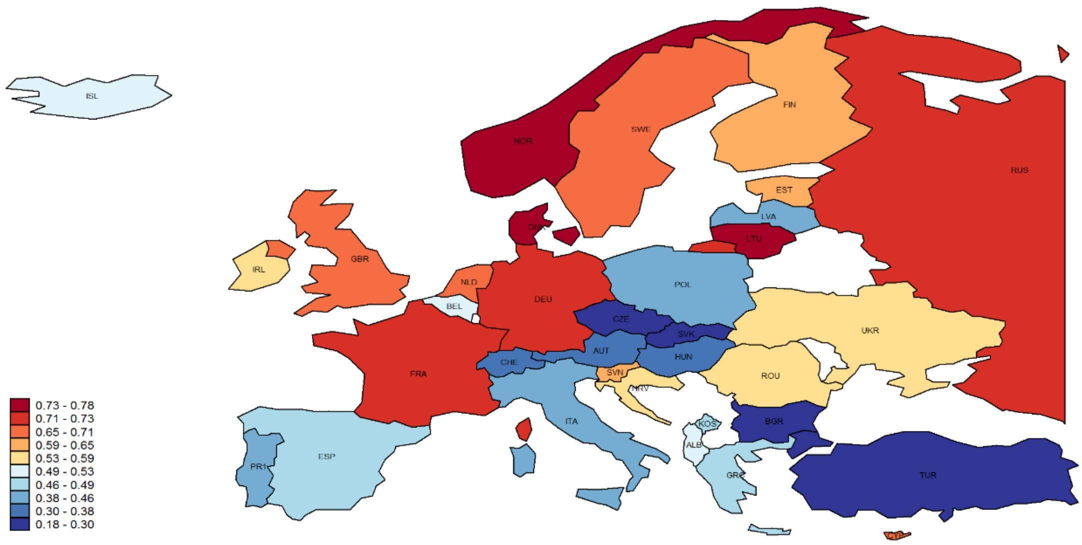

Fig. 22 Cross-country ranking of European countries according to the equality of educational opportunity in 1980-1985

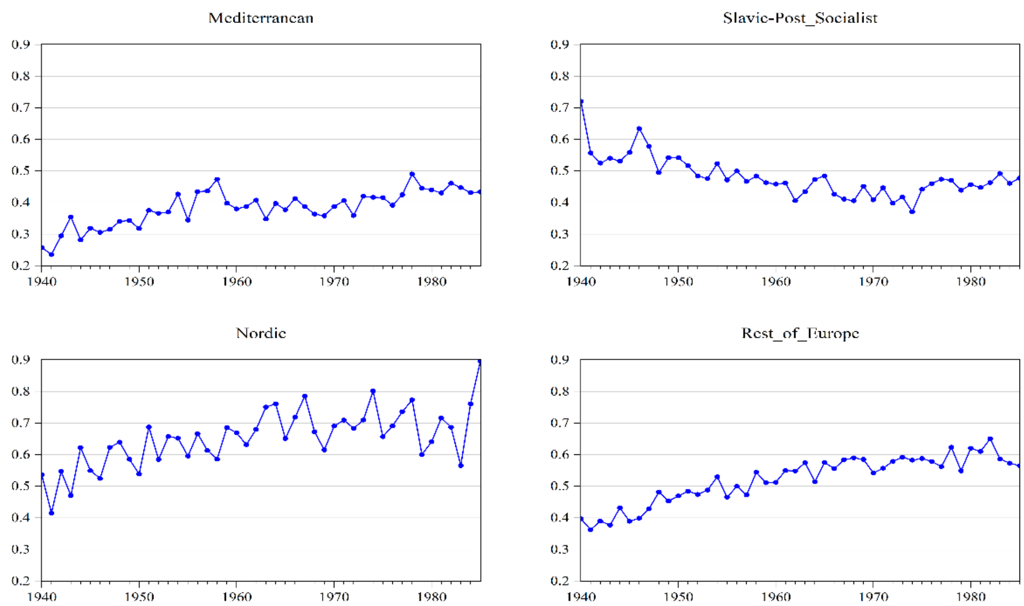

Fig. 23 Evolution of educational equality of opportunity across four main European regions between 1940-1985

Figure 23 shows the regional evolution of educational equality of opportunity, which is, calculated with the transition probabilities that have been estimated in the previous section. According to this, aside from Post-socialist countries, equality of opportunity has been continuously improving with each new cohort in Europe.

3.5.3 Intergenerational educational mobility dynamics conditional on maximum parental education and parental couple composition

During the initial part of the empirical analysis, it has been assumed that the educational attainment of a child is mainly determined by the parent who is more educated than the other. In this section, in addition to the education level of the more educated parent, the effect of less educated parent's educational attainment on the educational outcomes of the child will also be investigated. In order to accomplish this, the previous regression equation modified to include explanatory variables summarizing both of a child's parents' education levels on regional level will be estimated without any country and cohort clustering (I control cohort and country of origin with dummy variables):

$$E_i^* = \beta_t P_i + \sum_{j=1}^{6} (\alpha_{jt} D_{ijt}) + \sum_{k=1940}^{1985} \eta_k Y_k + \sum_{l=1}^{34} \theta_l C_l + u_{it}$$

where D_{ijt} is a dummy variable summarizing the education of both parents. By doing this, the effect of the inequality between parents' education on children's educational attainment and mobility prospects is aimed to be explored. Y_k and C_l are dummy variables that summarize individual i 's birth year and country information. Results from the estimation of this equation on regional basis are provided in Tables 11-14 (see Appendix B).

Table 11 shows that across the group of Mediterranean countries in families where the maximum parental education is medium, children from families where both parents are medium educated attend significantly higher levels of education compared to those coming from families where one of the parents are low educated. On the other hand, the identity of the parent with a relatively higher level of education does not seem to have a significant effect on child's education in families where one parent is low educated while the other has medium educational attainment. Interestingly, for families where maximum parental education is high it can be observed that children born into families where father is highly educated and mother is medium educated tend to attain a higher education level compared to other possibly family types where maximum parental education is high.

Tables 12 and 14 indicate that with respect to the effects of the parental couple composition on a child's educational attainment, the observations that have been made for the Mediterranean countries group are also valid for the Rest of Europe and the Post-socialist countries groups as well (the only difference is that now among families with medium educated parents, children born into those where mother is medium educated and father is low educated seem to attain a higher education level compared to those with medium educated fathers and low educated mothers). However according to Table 13, the parental couple effects seem to show some divergence from these observations in Nordic countries for families with medium educated parents. While children born into families where both parents are medium educated are still more likely to attain a higher education level in this family category, children with medium educated mothers and low educated fathers are now likely to attain a lower education level compared to those with medium educated fathers and low educated mothers.

Figures 24-29 (see Appendix A for figures 25-29) show the transition probabilities of children with medium and high-educated parents. According to these figures while transition probabilities show relatively low variance across family types where maximum parental education, a relatively larger variance can be noticed across transition probabilities across family types where maximum parental education is high.

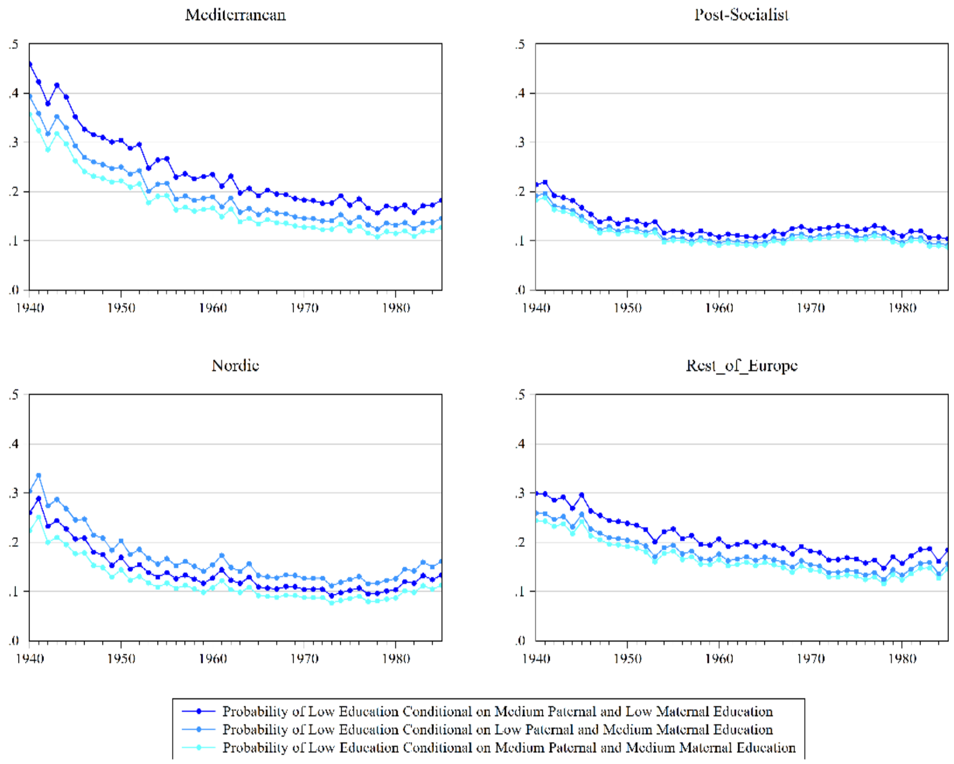

Fig. 24 Probability of low educational attainment conditional on medium parental education and parental couple structure across four main European regions between 1940-1985

4.5.4 Intergenerational educational mobility dynamics conditional on maximum parental education, parental couple composition and child's gender

In this section, the regression equation used in the previous section is modified by including gender-cohort fixed effects. The aim now is to capture the evolution of the effect of child's gender on her/his education across cohorts, and learn about potential differences in the intergenerational educational mobility patterns of children from both genders. The model used in this section is as follows:

$$E_i^* = \beta_t P_i + \sum_{j=1}^{6}(\alpha_{jt} D_{ijt}) + \sum_{k=1940}^{1985} \eta_k Y_k + \sum_{l=1}^{34} \theta_l C_l + \sum_{m=1940}^{1985} \gamma_m F_m + u_{it}$$

where F_m is a dummy variable that takes the value 1 if the respondent is born in year m and is a female, and zero otherwise. Results from the estimation of this regression equation are provided in Tables 15-18 (see Appendix B).

According to table 15, gender variables are negative and significant in general up to year 1959, and become insignificant after this year - which indicates that holding everything else constant, female children experienced a disadvantage compared to male children in terms of educational attainment up to the end of 1950s and this disadvantage disappeared after this period in the Mediterranean region. Table 16 shows a different pattern in Post-socialist countries where gender dummies have been negative and occasionally significant until 1954, and became positive and generally significant after this period- which suggests that, holding everything else constant, the disadvantage of female children turned into an advantage in Post-socialist countries.

Table 17 shows a similar scenario for Nordic countries where gender variables were statistically insignificant until 1951 and became positive and significant in general after this period. According to Table 18, the scenario observed in the Mediterranean countries group seems to be valid for the Rest of Europe group as well- negative and significant gender variables cease being statistically significant after mid-1960s.

Evolution of predicted transition probabilities conditional on medium parental education are provided in Figures 30-32 (see Appendix A). Figure 30 clearly demonstrates the convergence of high educational attainment probabilities of female children with medium educated parents to those of male children in the Mediterranean countries and Rest of Europe groups. For female children born in Post-socialist and Nordic countries, the highest probability of upward mobility generally belongs to those with medium educated fathers and mothers. In Nordic countries, gender effect sometimes even dominates the parental couple composition effect - for example, female children with medium educated fathers and low educated mothers seem more likely to attain higher education compared to male children with medium educated fathers and mothers.

Figures 33-35 (see Appendix A) show the educational mobility dynamics in families with highly educated parents, across all possible parent couples and children from both genders. Similar to the estimation results from the previous section, for both male and female children the probability of obtaining high educational attainment is lowest where mother has low education, and highest where mother has medium education across families where maximum parental education is high. Female children are relatively disadvantaged with respect to the prospect of high education in initial cohorts. However, this disadvantage tends to disappear gradually.

Furthermore, parental couple effects are dominated by changes in the magnitude of gender effects through time.

3.5.5 Within-cohort educational inequality and intergenerational educational mobility dynamics

In order to investigate the potential interaction between educational inequality and intergenerational educational mobility (in the sense of an educational Great Gatsby Curve Hypothesis (Corak, 2009)) educational Gini coefficients based on the years of schooling each respondent received have been calculated for each cohort and country in the dataset for the time period 1940-1985.

Figure 36 (see Appendix A) shows the evolution of within-cohort educational inequality across all cohorts and countries. The first interesting observation is the constancy of inequality across cohorts in general - i.e. except for Mediterranean countries, educational inequality does not exhibit substantial variation across cohorts. The second interesting observation is that the educational Gini coefficients are either centered around 0.2 (except for Mediterranean countries) or have been converging to 0.2 (in Mediterranean countries).

With respect to the relationship between within-cohort educational inequality and intergenerational persistence, there seems to exist two groups of countries that display substantially different dynamics. Figure 37 shows the scatterplots of educational inequality and persistence for each country in the dataset. According to these scatterplots, a positive relationship between inequality and persistence can be commonly observed across all Mediterranean countries - indicating that like in the case of income inequality and persistence depicted by Corak (2009) in a cross-country setting, there is a positive relationship in the case of educational inequality and persistence through time in each Mediterranean country. In the non-Mediterranean Europe, it is not possible to identify any common pattern, and this is mainly caused because of the fact that educational inequality remains nearly constant across cohorts in this group of countries.

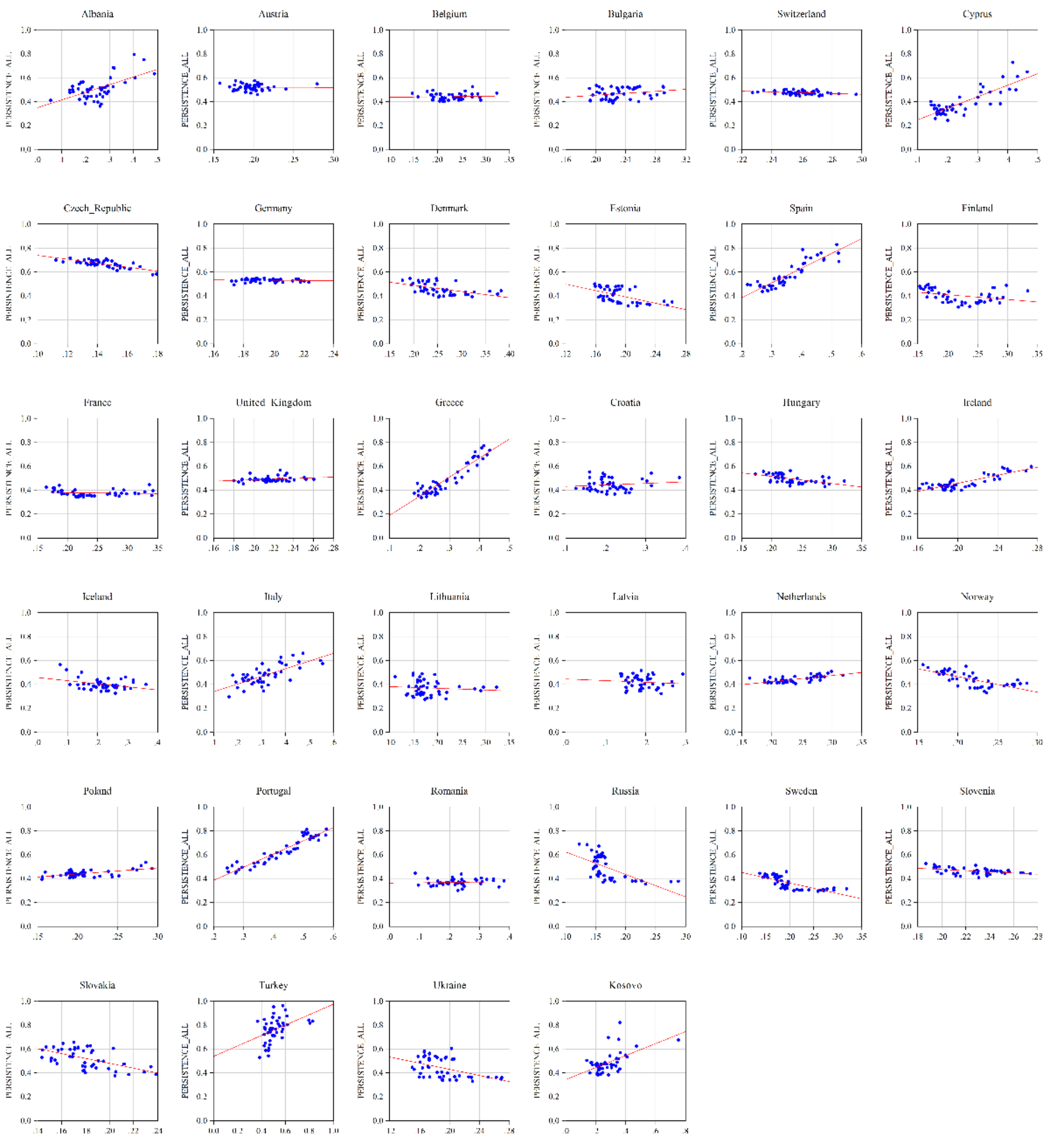

Fig. 37 Educational Great Gatsby curves inequality across European countries between 1940-1985

3.6 Conclusion

In this study, using a different empirical approach compared to existing studies in the literature of intergenerational educational mobility, the evolution of educational mobility and inequality across various cohorts, countries and regions in Europe have been investigated mainly using the data from the first seven waves of the European Social Survey.

The results of the empirical analysis show that intergenerational educational mobility dynamics have evolved remarkably differently across main regions of Europe. Specifically, intergenerational educational persistence has declined substantially in the Mediterranean region, increased dramatically in the group of post-socialist countries and followed a mild U-shape across Nordic countries and the rest of Europe. The divergence in the mobility patterns are both due to divergence in the distribution of families according to parents' education, and the divergence of transition probabilities conditional on maximum parental education.

Moreover, aside from the maximum parental education observed in a family, the parental couple composition (in terms of the identity of the parent with relatively high educational attainment) seems to have important effects on children's educational outcomes and prospects of mobility. With respect to the effects of gender on educational mobility, results indicate that female children have been relatively disadvantaged in the early cohorts of the sample used in this study. However, depending on the country/region, female children either converge to or surpass male children in terms of educational attainment and mobility.

Finally, with respect to educational inequality, the results from this study indicate that except for Mediterranean countries, educational Gini coefficients are mainly centered around 0.2 and do not change substantially across cohorts. On the other hand, educational inequality uniformly decreases with each new cohort across Mediterranean countries and shows a positive relationship with intergenerational educational persistence - which lends credence to the existence of an educational Great Gatsby Curve in the group of Mediterranean countries.

APPENDIX A

FIGURES 25-36

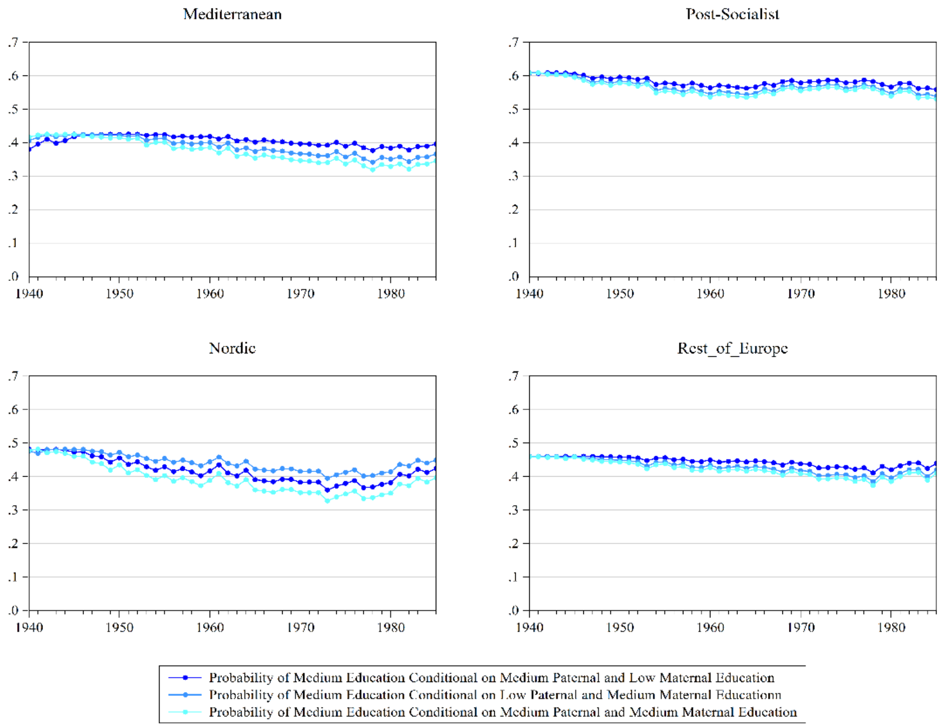

Fig. 25 Probability of medium educational attainment conditional on medium parental education and parental couple structure across four main European regions between 1940-1985

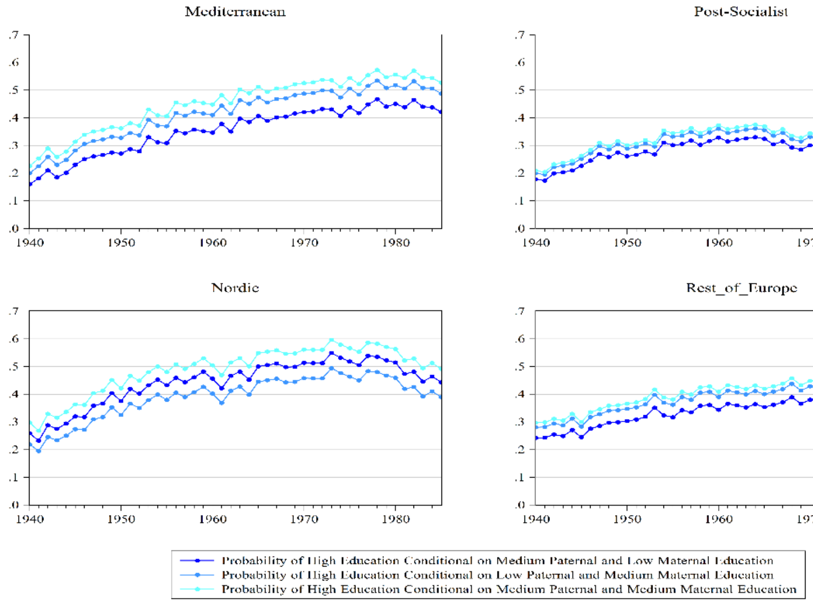

Fig. 26 Probability of high educational attainment conditional on medium parental education and parental couple structure across four main European regions between 1940-1985

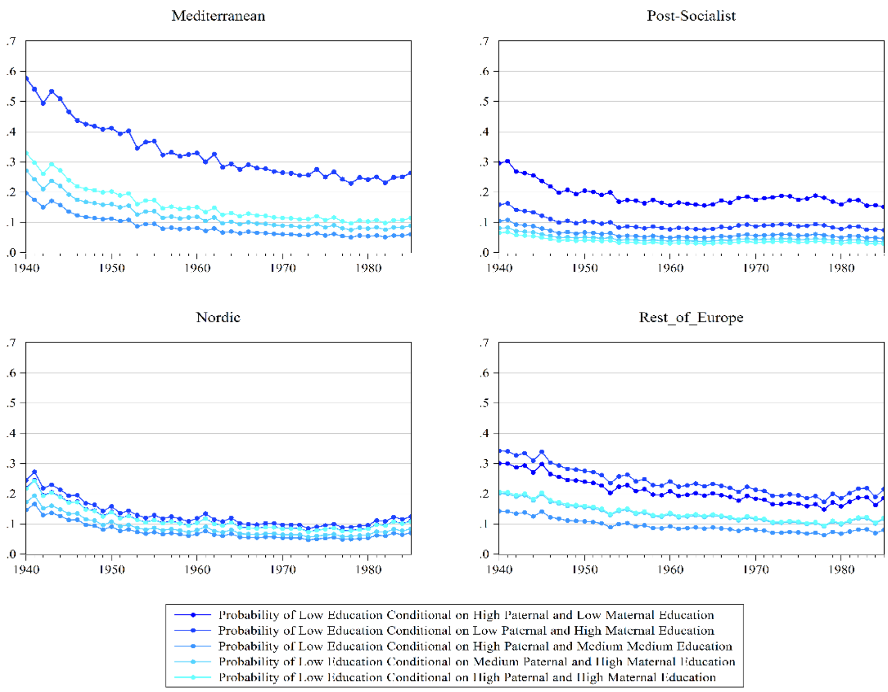

Fig. 27 Probability of low educational attainment conditional on high parental education and parental couple structure across four main European regions between 1940-1985

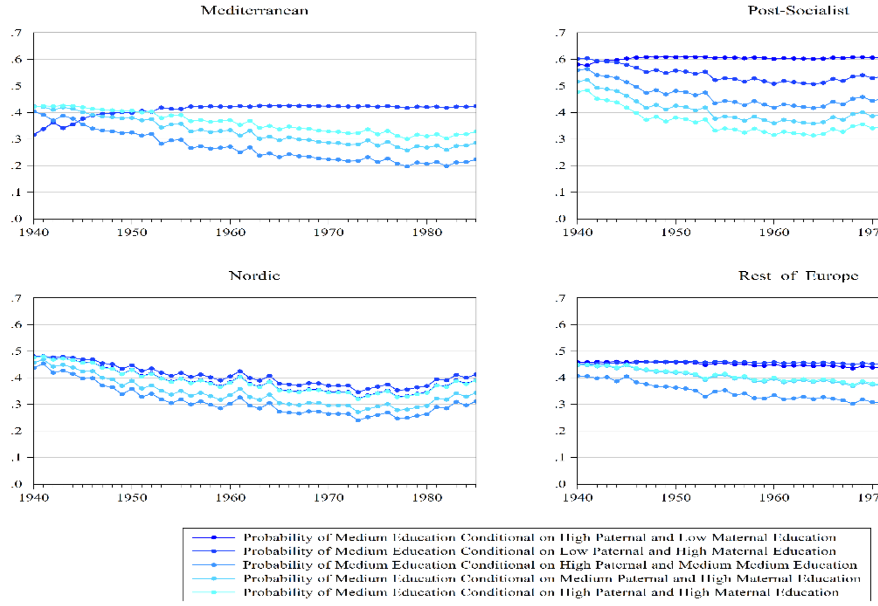

Fig. 28 Probability of medium educational attainment conditional on high parental education and parental couple structure across four main European regions between 1940-1985

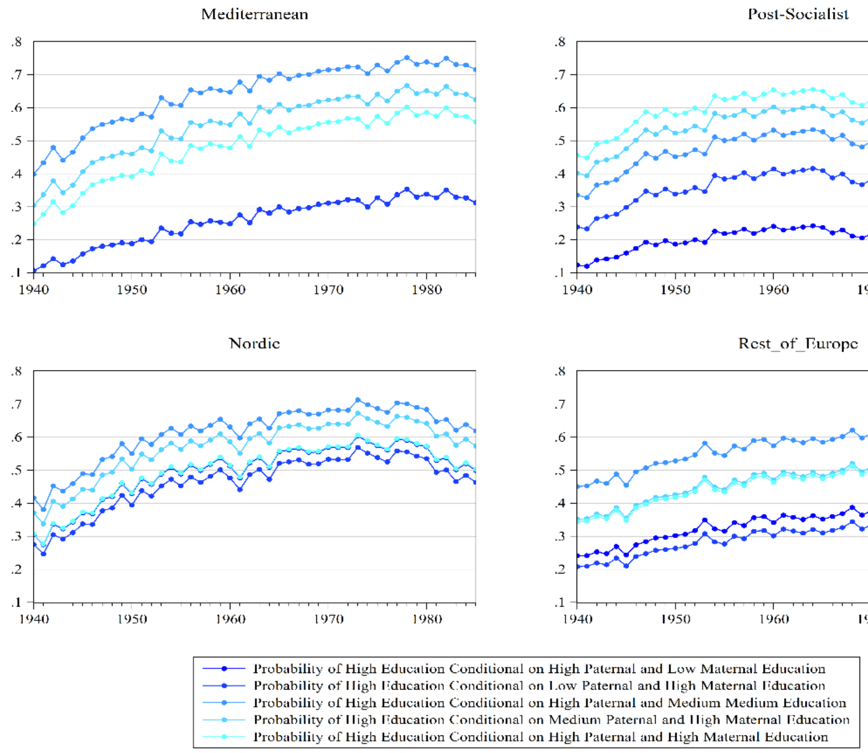

Fig. 29 Probability of high educational attainment conditional on high parental education and parental couple structure across four main European regions between 1940-1985

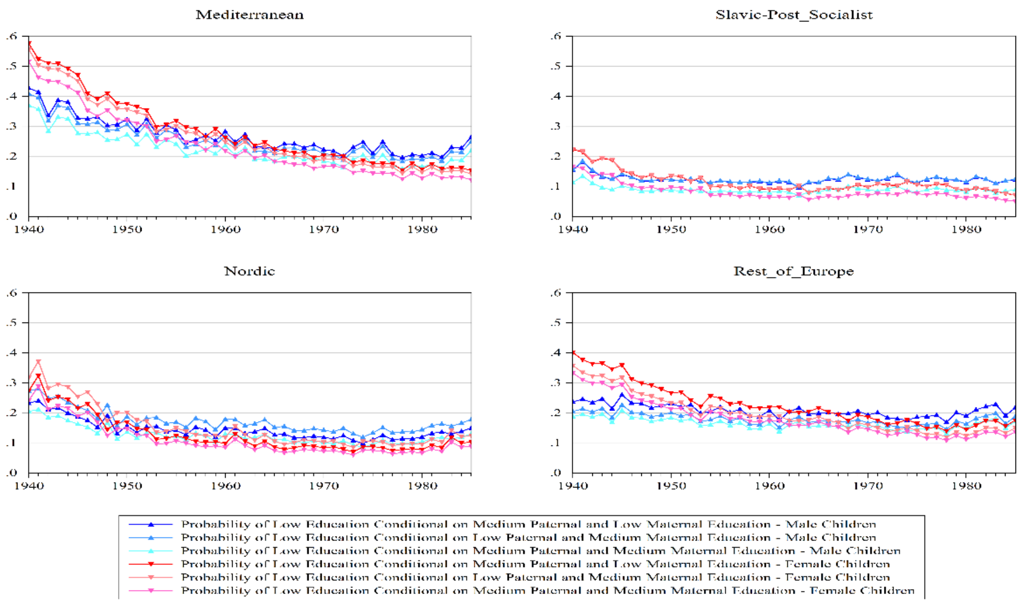

Fig. 30 Probability of low educational attainment conditional on medium parental education and child gender across four main European regions between 1940-1985

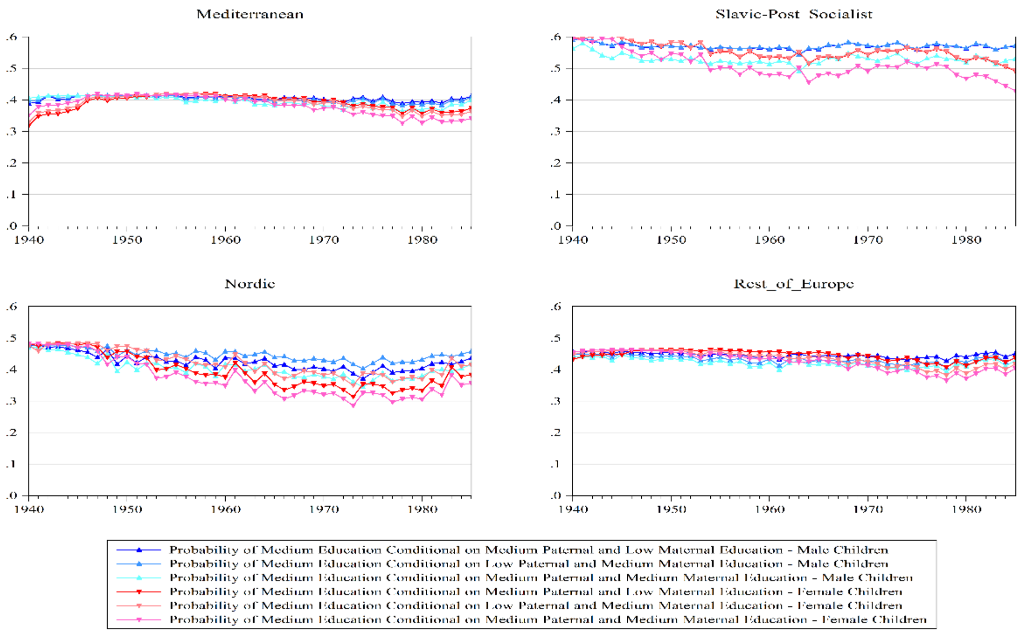

Fig. 31 Probability of medium educational attainment conditional on medium parental education and child gender across four main European regions between 1940-1985

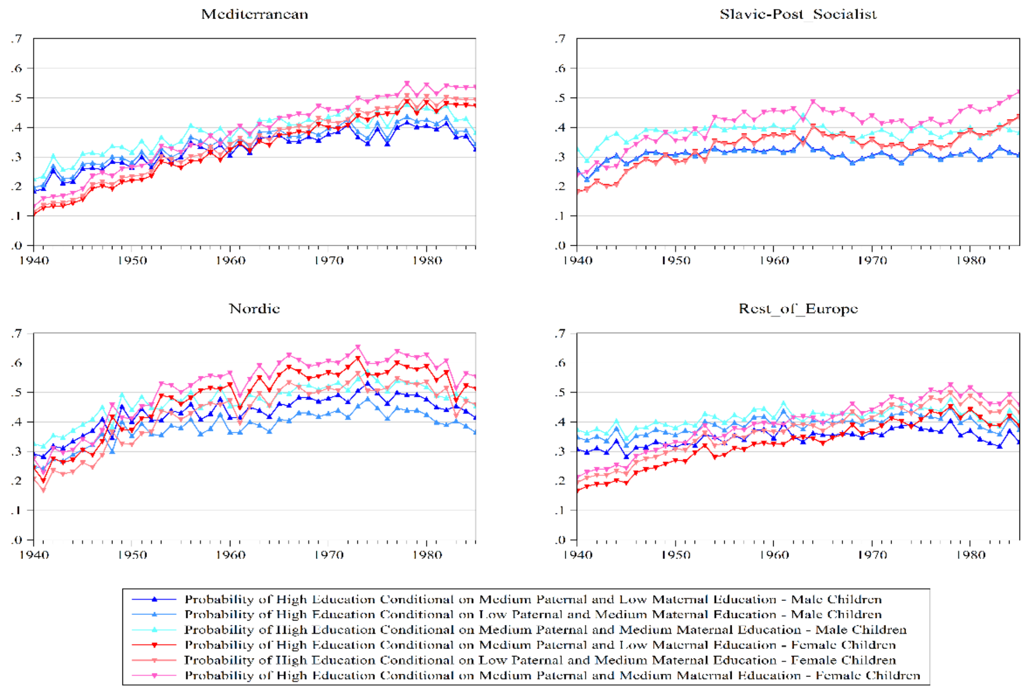

Fig. 32 Probability of high educational attainment conditional on medium parental education and child gender across four main European regions between 1940-1985

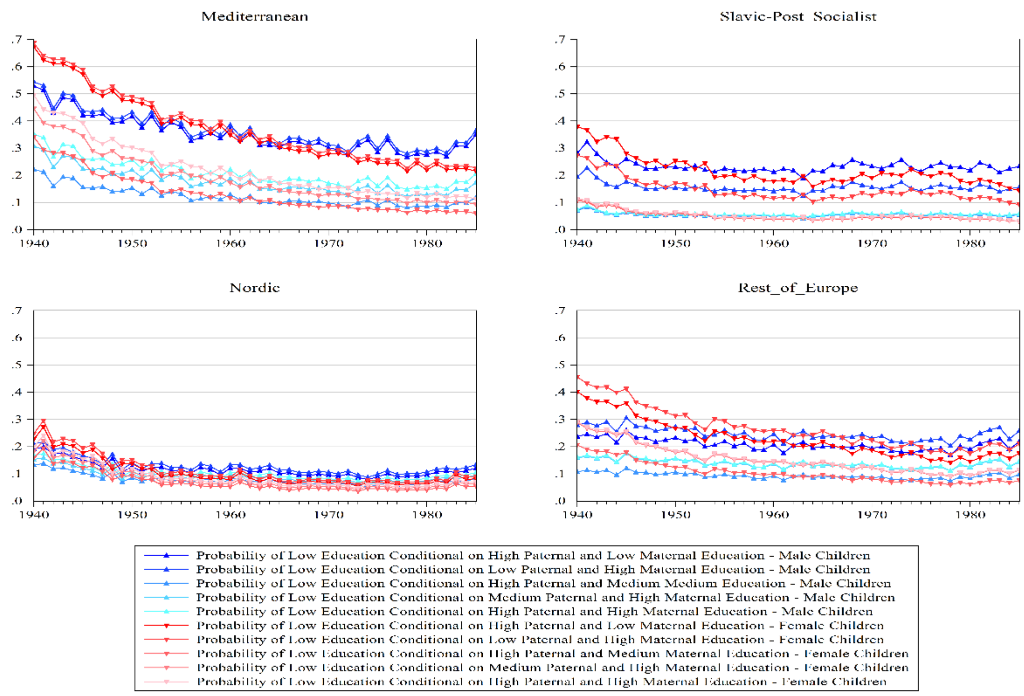

Fig. 33 Probability of low educational attainment conditional on high parental education and child gender across four main European regions between 1940-1985

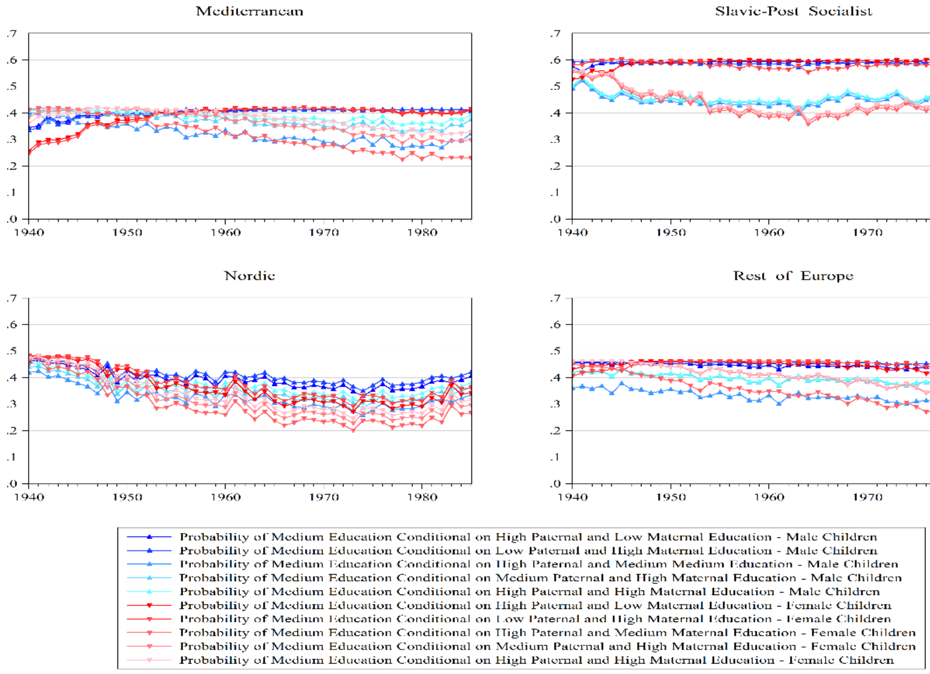

Fig. 34 Probability of medium educational attainment conditional on high parental education and child gender across four main European regions between 1940-1985

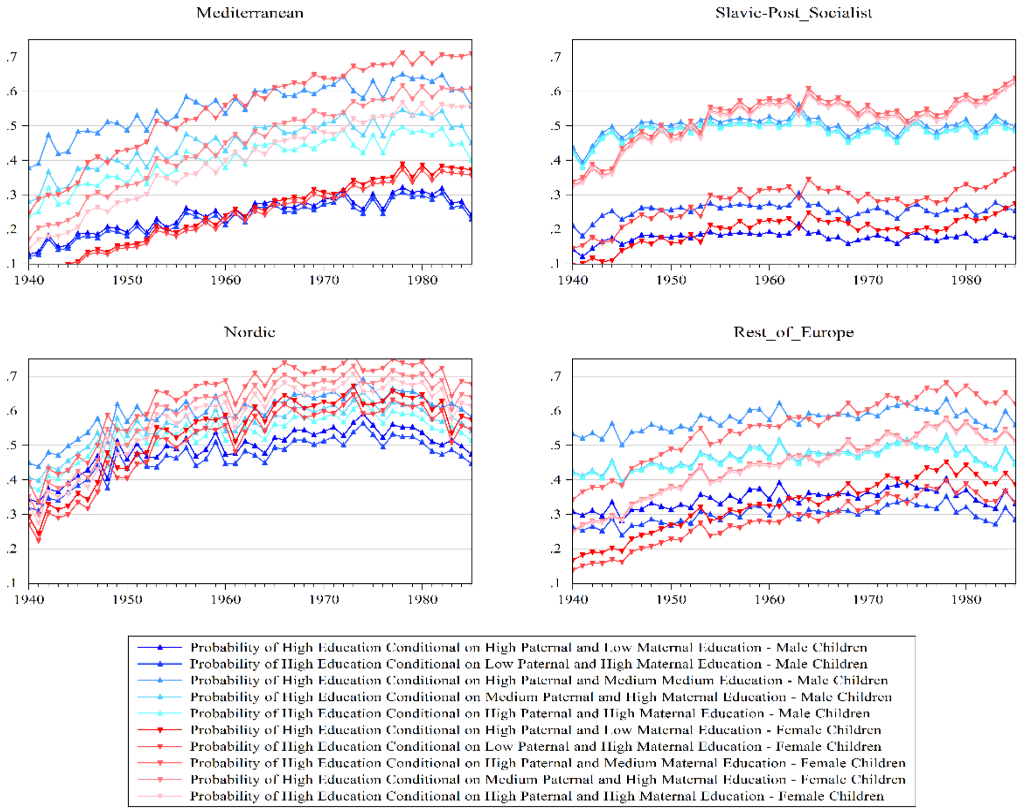

Fig. 35 Probability of high educational attainment conditional on high parental education and child gender across four main European regions between 1940-1985

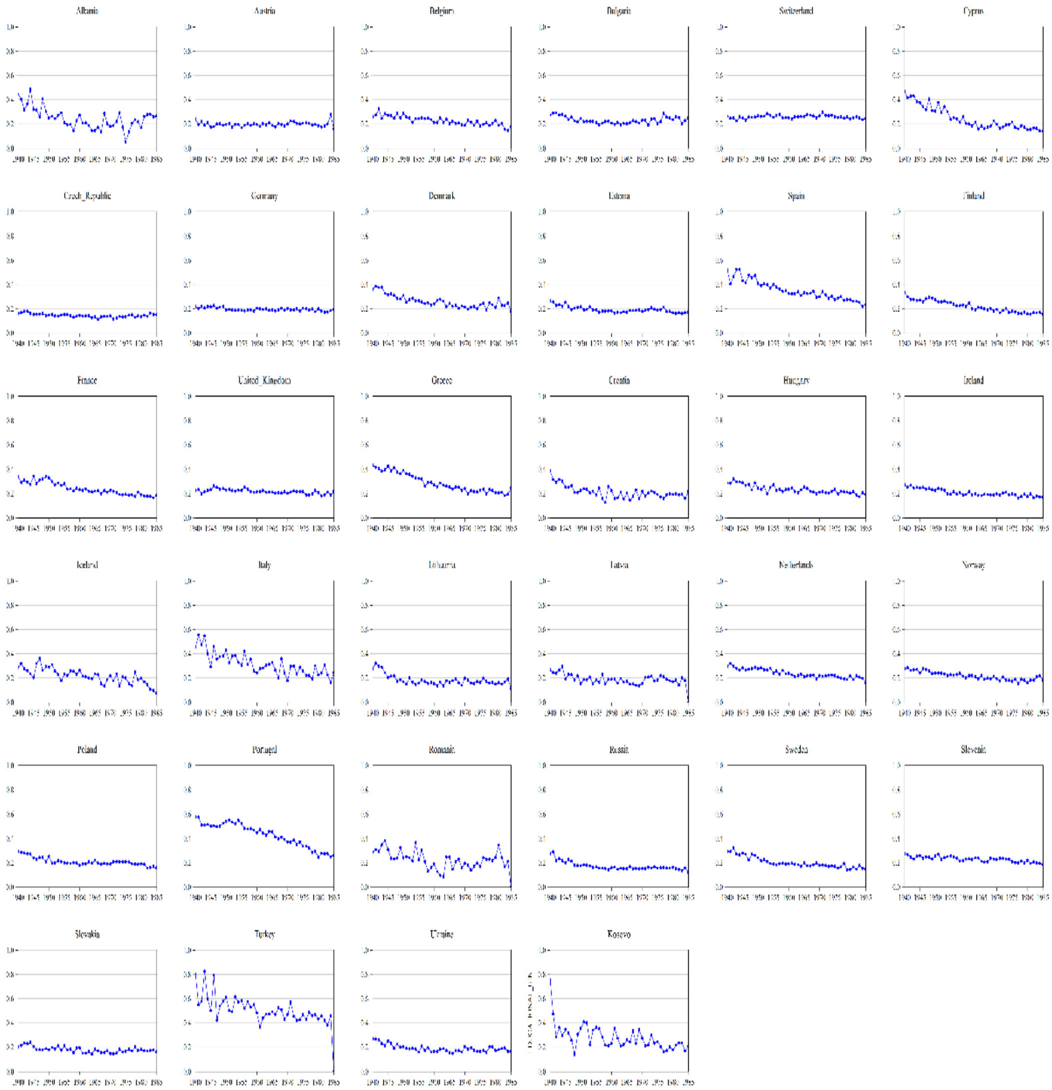

Fig. 36 Evolution of educational inequality across European countries between 1940-1985

APPENDIX B

TABLES 7-18

Table 7. Output of Logistic Regressions where the Main Independent Variable is the Maximum Parental Education – Mediterranean Country Group

Variable	Coefficient	Std.Error	P-value
maxparentedu3lvl	0.654	0.012	0.000
1941.birthyear	0.147	0.101	0.146
1942.birthyear	0.314	0.097	0.001
1943.birthyear	0.199	0.098	0.041
1944.birthyear	0.263	0.095	0.006
1945.birthyear	0.430	0.094	0.000
1946.birthyear	0.547	0.091	0.000
1947.birthyear	0.548	0.091	0.000
1948.birthyear	0.626	0.090	0.000
1949.birthyear	0.694	0.090	0.000
1950.birthyear	0.682	0.089	0.000
1951.birthyear	0.751	0.090	0.000
1952.birthyear	0.736	0.090	0.000
1953.birthyear	0.991	0.088	0.000
1954.birthyear	0.881	0.089	0.000
1955.birthyear	0.914	0.089	0.000
1956.birthyear	1.080	0.088	0.000
1957.birthyear	1.043	0.088	0.000
1958.birthyear	1.098	0.088	0.000
1959.birthyear	1.084	0.088	0.000
1960.birthyear	1.130	0.085	0.000
1961.birthyear	1.233	0.088	0.000
1962.birthyear	1.143	0.087	0.000
1963.birthyear	1.312	0.087	0.000
1964.birthyear	1.319	0.087	0.000
1965.birthyear	1.404	0.086	0.000
1966.birthyear	1.371	0.086	0.000
1967.birthyear	1.414	0.086	0.000
1968.birthyear	1.442	0.086	0.000
1969.birthyear	1.517	0.086	0.000
1970.birthyear	1.501	0.086	0.000
1971.birthyear	1.506	0.086	0.000
1972.birthyear	1.620	0.085	0.000
1973.birthyear	1.616	0.086	0.000
1974.birthyear	1.545	0.086	0.000
1975.birthyear	1.691	0.085	0.000
1976.birthyear	1.618	0.087	0.000
1977.birthyear	1.737	0.086	0.000
1978.birthyear	1.869	0.089	0.000
1979.birthyear	1.763	0.090	0.000
1980.birthyear	1.822	0.089	0.000
1981.birthyear	1.769	0.094	0.000
1982.birthyear	1.845	0.098	0.000
1983.birthyear	1.721	0.100	0.000
1984.birthyear	1.778	0.106	0.000
1985.birthyear	1.594	0.116	0.000
Cyprus.dummy	1.060	0.075	0.000
Spain.dummy	0.090	0.071	0.203
France.dummy	0.893	0.070	0.000
Greece.dummy	0.530	0.071	0.000
Hungary.dummy	0.631	0.071	0.000
Israel.dummy	1.188	0.072	0.000

Italy.dummy	0.237	0.083	0.004
Portugal.dummy	-0.703	0.072	0.000
Turkey.dummy	-1.157	0.080	0.000
cons	2.040	0.097	
cons	3.931	0.098	
Observations	54171		
PseudoR2	0.12393		

Table 8. Output of Logistic Regressions where the Main Independent Variable is the Maximum Parental Education – Post-Socialist Country Group

Variable	Coefficient	Std. Error	P-value
maxparentedu.3lvl	0.685	0.011	0.000
1941.birth.year	-0.067	0.078	0.388
1942.birth.year	0.186	0.080	0.020
1943.birth.year	0.276	0.080	0.001
1944.birth.year	0.345	0.080	0.000
1945.birth.year	0.430	0.079	0.000
1946.birth.year	0.517	0.076	0.000
1947.birth.year	0.615	0.075	0.000
1948.birth.year	0.605	0.074	0.000
1949.birth.year	0.661	0.073	0.000
1950.birth.year	0.638	0.072	0.000
1951.birth.year	0.636	0.074	0.000
1952.birth.year	0.734	0.073	0.000
1953.birth.year	0.718	0.074	0.000
1954.birth.year	0.878	0.074	0.000
1955.birth.year	0.869	0.073	0.000
1956.birth.year	0.873	0.073	0.000
1957.birth.year	0.906	0.073	0.000
1958.birth.year	0.889	0.073	0.000
1959.birth.year	0.937	0.074	0.000
1960.birth.year	1.000	0.073	0.000
1961.birth.year	0.947	0.075	0.000
1962.birth.year	0.982	0.074	0.000
1963.birth.year	1.021	0.076	0.000
1964.birth.year	1.090	0.075	0.000
1965.birth.year	1.067	0.075	0.000
1966.birth.year	0.959	0.076	0.000
1967.birth.year	0.996	0.076	0.000
1968.birth.year	0.956	0.075	0.000
1969.birth.year	0.914	0.076	0.000
1970.birth.year	1.009	0.074	0.000
1971.birth.year	0.957	0.076	0.000
1972.birth.year	0.981	0.075	0.000
1973.birth.year	0.958	0.076	0.000
1974.birth.year	0.986	0.075	0.000
1975.birth.year	1.055	0.076	0.000
1976.birth.year	1.072	0.076	0.000
1977.birth.year	0.993	0.077	0.000
1978.birth.year	1.037	0.078	0.000
1979.birth.year	1.118	0.078	0.000
1980.birth.year	1.190	0.078	0.000
1981.birth.year	1.046	0.081	0.000
1982.birth.year	1.125	0.084	0.000
1983.birth.year	1.252	0.085	0.000
1984.birth.year	1.255	0.088	0.000
1985.birth.year	1.265	0.097	0.000
Czech.Republic.dummy	-0.106	0.032	0.001
Estonia.dummy	0.463	0.035	0.000
Croatia.dummy	0.006	0.049	0.908
Lithuania.dummy	0.474	0.047	0.000
Latvia.dummy	0.181	0.059	0.002
Poland.dummy	-0.302	0.034	0.000
Romania.dummy	-0.675	0.057	0.000
Russia.dummy	1.424	0.037	0.000
Slovenia.dummy	0.011	0.036	0.756
Slovakia.dummy	0.045	0.035	0.200
Ukraine.dummy	1.397	0.037	0.000
Kosovo.dummy	-1.114	0.070	0.000
cons	0.440	0.061	
cons	3.388	0.063	

Observations	67460		
PseudoR2	0.109		

Table 9. Output of Logistic Regressions where the Main Independent Variable is the Maximum Parental Education – Nordic Country Group

Variable	Coefficient	Std.Error	P-value
maxparentedu.3lvl	0.554	0.013	0.000
1941.birth.year	-0.153	0.110	0.164
1942.birth.year	0.143	0.109	0.190
1943.birth.year	0.093	0.105	0.373
1944.birth.year	0.163	0.104	0.118
1945.birth.year	0.289	0.101	0.004
1946.birth.year	0.276	0.100	0.006
1947.birth.year	0.474	0.101	0.000
1948.birth.year	0.492	0.103	0.000
1949.birth.year	0.655	0.101	0.000
1950.birth.year	0.535	0.102	0.000
1951.birth.year	0.714	0.102	0.000
1952.birth.year	0.655	0.102	0.000
1953.birth.year	0.771	0.103	0.000
1954.birth.year	0.846	0.103	0.000
1955.birth.year	0.781	0.102	0.000
1956.birth.year	0.880	0.103	0.000
1957.birth.year	0.824	0.102	0.000
1958.birth.year	0.901	0.101	0.000
1959.birth.year	0.980	0.103	0.000
1960.birth.year	0.892	0.102	0.000
1961.birth.year	0.750	0.101	0.000
1962.birth.year	0.918	0.101	0.000
1963.birth.year	0.994	0.102	0.000
1964.birth.year	0.872	0.100	0.000
1965.birth.year	1.049	0.099	0.000
1966.birth.year	1.092	0.101	0.000
1967.birth.year	1.132	0.102	0.000
1968.birth.year	1.086	0.102	0.000
1969.birth.year	1.068	0.103	0.000
1970.birth.year	1.128	0.105	0.000
1971.birth.year	1.121	0.103	0.000
1972.birth.year	1.129	0.103	0.000
1973.birth.year	1.275	0.107	0.000
1974.birth.year	1.216	0.105	0.000
1975.birth.year	1.159	0.104	0.000
1976.birth.year	1.108	0.105	0.000
1977.birth.year	1.244	0.107	0.000
1978.birth.year	1.236	0.113	0.000
1979.birth.year	1.176	0.113	0.000
1980.birth.year	1.153	0.117	0.000
1981.birth.year	1.015	0.117	0.000
1982.birth.year	1.046	0.123	0.000
1983.birth.year	0.906	0.125	0.000
1984.birth.year	0.965	0.143	0.000
1985.birth.year	0.875	0.139	0.000
Finland.dummy	-0.159	0.030	0.000
Iceland.dummy	-0.246	0.069	0.000
Norway.dummy	-0.022	0.030	0.477
Sweden.dummy	-0.558	0.030	0.000
cons	0.001	0.085	
cons	2.107	0.085	
Observations	35951		
PseudoR2	0.0564		

Table 10. Output of Logistic Regressions where the Main Independent Variable is the Maximum Parental Education – Rest of Europe

Variable	Coefficient	Std.Error	P-value
maxparentedu.3lvl	0.661	0.010	0.000
1941.birth.year	0.007	0.073	0.928
1942.birth.year	0.052	0.073	0.476
1943.birth.year	0.038	0.073	0.599
1944.birth.year	0.140	0.071	0.048
1945.birth.year	0.024	0.072	0.741
1946.birth.year	0.182	0.071	0.011
1947.birth.year	0.244	0.070	0.000
1948.birth.year	0.293	0.070	0.000
1949.birth.year	0.282	0.070	0.000
1950.birth.year	0.310	0.069	0.000
1951.birth.year	0.334	0.070	0.000
1952.birth.year	0.392	0.069	0.000
1953.birth.year	0.528	0.070	0.000
1954.birth.year	0.419	0.070	0.000
1955.birth.year	0.396	0.069	0.000
1956.birth.year	0.512	0.068	0.000
1957.birth.year	0.476	0.069	0.000
1958.birth.year	0.588	0.068	0.000
1959.birth.year	0.592	0.068	0.000
1960.birth.year	0.550	0.066	0.000
1961.birth.year	0.633	0.067	0.000
1962.birth.year	0.606	0.066	0.000
1963.birth.year	0.603	0.066	0.000
1964.birth.year	0.628	0.067	0.000
1965.birth.year	0.599	0.066	0.000
1966.birth.year	0.629	0.066	0.000
1967.birth.year	0.680	0.067	0.000
1968.birth.year	0.746	0.068	0.000
1969.birth.year	0.642	0.068	0.000
1970.birth.year	0.723	0.067	0.000
1971.birth.year	0.735	0.069	0.000
1972.birth.year	0.854	0.069	0.000
1973.birth.year	0.820	0.071	0.000
1974.birth.year	0.803	0.071	0.000
1975.birth.year	0.838	0.071	0.000
1976.birth.year	0.895	0.072	0.000
1977.birth.year	0.870	0.072	0.000
1978.birth.year	1.004	0.074	0.000
1979.birth.year	0.811	0.075	0.000
1980.birth.year	0.902	0.076	0.000
1981.birth.year	0.804	0.080	0.000
1982.birth.year	0.732	0.084	0.000
1983.birth.year	0.688	0.091	0.000
1984.birth.year	0.850	0.096	0.000
1985.birth.year	0.721	0.096	0.000
Belgium.dummy	0.365	0.030	0.000
Switzerland.dummy	0.430	0.030	0.000
Germany.dummy	0.433	0.027	0.000
United.Kingdom.dummy	0.005	0.031	0.880
Ireland.dummy	0.231	0.029	0.000
Luxembourg.dummy	-0.197	0.047	0.000
Netherlands.dummy	0.074	0.030	0.013
cons	0.875	0.057	
cons	2.844	0.058	
Observations	70542		
PseudoR2	0.057		

Table 11. Output of Logistic Regressions where Independent Variables are the Maximum Parental Education and Dummy Variables Summarizing Both Parents' Education – Mediterranean Country Group

Variable	Coefficient	Std.Error	P-value
maxparentedu.3lvl	1.079	0.024	0.000
d12	0.068	0.060	0.259
d22	0.324	0.046	0.000
d31	-1.549	0.059	0.000
d13	-1.588	0.080	0.000
d23	-0.548	0.090	0.000
d33	-0.836	0.056	0.000
1941.birth.year	0.201	0.113	0.074
1942.birth.year	0.334	0.109	0.002
1943.birth.year	0.279	0.109	0.010
1944.birth.year	0.274	0.106	0.010
1945.birth.year	0.498	0.103	0.000
1946.birth.year	0.639	0.101	0.000
1947.birth.year	0.644	0.100	0.000
1948.birth.year	0.644	0.100	0.000
1949.birth.year	0.750	0.100	0.000
1950.birth.year	0.691	0.099	0.000
1951.birth.year	0.825	0.101	0.000
1952.birth.year	0.786	0.099	0.000
1953.birth.year	1.060	0.098	0.000
1954.birth.year	0.944	0.099	0.000
1955.birth.year	0.970	0.099	0.000
1956.birth.year	1.180	0.097	0.000
1957.birth.year	1.149	0.097	0.000
1958.birth.year	1.203	0.097	0.000
1959.birth.year	1.187	0.096	0.000
1960.birth.year	1.230	0.094	0.000
1961.birth.year	1.327	0.096	0.000
1962.birth.year	1.263	0.096	0.000
1963.birth.year	1.428	0.096	0.000
1964.birth.year	1.411	0.095	0.000
1965.birth.year	1.508	0.094	0.000
1966.birth.year	1.508	0.095	0.000
1967.birth.year	1.524	0.095	0.000
1968.birth.year	1.519	0.094	0.000
1969.birth.year	1.587	0.095	0.000
1970.birth.year	1.613	0.094	0.000
1971.birth.year	1.626	0.095	0.000
1972.birth.year	1.699	0.094	0.000
1973.birth.year	1.708	0.095	0.000
1974.birth.year	1.654	0.095	0.000
1975.birth.year	1.798	0.094	0.000
1976.birth.year	1.705	0.096	0.000
1977.birth.year	1.818	0.094	0.000
1978.birth.year	1.936	0.097	0.000
1979.birth.year	1.834	0.100	0.000
1980.birth.year	1.910	0.099	0.000
1981.birth.year	1.809	0.103	0.000
1982.birth.year	1.857	0.107	0.000
1983.birth.year	1.737	0.109	0.000
1984.birth.year	1.786	0.118	0.000
1985.birth.year	1.570	0.128	0.000
Cyprus.dummy	1.073	0.075	0.000
Spain.dummy	0.223	0.071	0.002
France.dummy	0.902	0.070	0.000
Greece.dummy	0.587	0.071	0.000
Israel.dummy	1.169	0.072	0.000
Italy.dummy	0.293	0.083	0.000
Portugal.dummy	-0.517	0.072	0.000
Turkey.dummy	-0.999	0.080	0.000
cons	2.720	0.106	
cons	4.490	0.107	
Observations	47264		
PseudoR2	0.1508		

Table 12. Output of Logistic Regressions where Independent Variables are the Maximum Parental Education and Dummy Variables Summarizing Both Parents' Education – Post-Socialist Country Group

Variable	Coefficient	Std.Error	P-value
maxparentedu.3lvl	0.948	0.016	0.000
d12	0.001	0.037	0.982
d22	0.407	0.021	0.000
d31	-1.760	0.046	0.000
d13	-1.284	0.064	0.000
d23	-0.067	0.050	0.175
d33	-0.076	0.037	0.039
1941.birth.year	-0.085	0.075	0.257
1942.birth.year	0.193	0.076	0.011
1943.birth.year	0.197	0.076	0.010
1944.birth.year	0.293	0.076	0.000
1945.birth.year	0.386	0.076	0.000
1946.birth.year	0.432	0.073	0.000
1947.birth.year	0.508	0.072	0.000
1948.birth.year	0.550	0.071	0.000
1949.birth.year	0.557	0.070	0.000
1950.birth.year	0.533	0.069	0.000
1951.birth.year	0.544	0.070	0.000
1952.birth.year	0.606	0.070	0.000
1953.birth.year	0.599	0.070	0.000
1954.birth.year	0.743	0.070	0.000
1955.birth.year	0.713	0.069	0.000
1956.birth.year	0.712	0.070	0.000
1957.birth.year	0.758	0.070	0.000
1958.birth.year	0.713	0.070	0.000
1959.birth.year	0.774	0.071	0.000
1960.birth.year	0.797	0.070	0.000
1961.birth.year	0.763	0.072	0.000
1962.birth.year	0.764	0.071	0.000
1963.birth.year	0.802	0.073	0.000
1964.birth.year	0.850	0.072	0.000
1965.birth.year	0.831	0.072	0.000
1966.birth.year	0.689	0.073	0.000
1967.birth.year	0.750	0.073	0.000
1968.birth.year	0.680	0.072	0.000
1969.birth.year	0.660	0.073	0.000
1970.birth.year	0.684	0.072	0.000
1971.birth.year	0.643	0.072	0.000
1972.birth.year	0.684	0.072	0.000
1973.birth.year	0.628	0.073	0.000
1974.birth.year	0.617	0.072	0.000
1975.birth.year	0.696	0.073	0.000
1976.birth.year	0.699	0.072	0.000
1977.birth.year	0.649	0.074	0.000
1978.birth.year	0.676	0.075	0.000
1979.birth.year	0.729	0.075	0.000
1980.birth.year	0.778	0.075	0.000
1981.birth.year	0.664	0.078	0.000
1982.birth.year	0.750	0.081	0.000
1983.birth.year	0.825	0.082	0.000
1984.birth.year	0.841	0.085	0.000
1985.birth.year	0.857	0.093	0.000
Czech.Republic.dummy	-0.321	0.033	0.000
Estoni,a.dummy	0.504	0.035	0.000
Croatia.dummy	0.062	0.049	0.207
Hungary.dummy	-0.207	0.035	0.000
Lithuania.dummy	0.604	0.048	0.000
Latvia.dummy	0.209	0.059	0.000
Poland.dummy	-0.238	0.034	0.000

Romania.dummy	-0.589	0.058	0.000
Russia.dummy	1.610	0.038	0.000
Slovenia.dummy	0.019	0.036	0.589
Slovakia.dummy	-0.030	0.035	0.392
Ukraine.dummy	1.523	0.037	0.000
Kosovo.dummy	-0.931	0.070	0.000
cons	0.676	0.060	
cons	3.720	0.062	
Observations	74367		
PseudoR2	0.1259		

Table 13. Output of Logistic Regressions where Independent Variables are the Maximum Parental Education and Dummy Variables Summarizing Both Parents' Education – Nordic Country Group

Variable	Coefficient	Std. Error	P-value
maxparentedu.3lvl	0.686	0.022	0.000
d12	-0.198	0.046	0.000
d22	0.168	0.036	0.000
d31	-0.428	0.058	0.000
d13	-0.551	0.078	0.000
d23	-0.166	0.066	0.012
d33	-0.273	0.045	0.000
1941.birth.year	-0.155	0.110	0.157
1942.birth.year	0.142	0.109	0.192
1943.birth.year	0.091	0.105	0.384
1944.birth.year	0.168	0.104	0.109
1945.birth.year	0.287	0.101	0.004
1946.birth.year	0.276	0.100	0.006
1947.birth.year	0.473	0.101	0.000
1948.birth.year	0.495	0.103	0.000
1949.birth.year	0.657	0.101	0.000
1950.birth.year	0.534	0.102	0.000
1951.birth.year	0.711	0.102	0.000
1952.birth.year	0.656	0.102	0.000
1953.birth.year	0.769	0.103	0.000
1954.birth.year	0.839	0.103	0.000
1955.birth.year	0.780	0.102	0.000
1956.birth.year	0.871	0.103	0.000
1957.birth.year	0.814	0.103	0.000
1958.birth.year	0.895	0.101	0.000
1959.birth.year	0.977	0.103	0.000
1960.birth.year	0.868	0.102	0.000
1961.birth.year	0.727	0.101	0.000
1962.birth.year	0.903	0.101	0.000
1963.birth.year	0.975	0.102	0.000
1964.birth.year	0.861	0.100	0.000
1965.birth.year	1.037	0.099	0.000
1966.birth.year	1.068	0.101	0.000
1967.birth.year	1.103	0.102	0.000
1968.birth.year	1.052	0.102	0.000
1969.birth.year	1.045	0.103	0.000
1970.birth.year	1.091	0.105	0.000
1971.birth.year	1.091	0.104	0.000
1972.birth.year	1.090	0.103	0.000
1973.birth.year	1.241	0.108	0.000
1974.birth.year	1.177	0.105	0.000
1975.birth.year	1.119	0.104	0.000
1976.birth.year	1.073	0.105	0.000
1977.birth.year	1.202	0.107	0.000
1978.birth.year	1.190	0.113	0.000
1979.birth.year	1.134	0.113	0.000
1980.birth.year	1.110	0.117	0.000
1981.birth.year	0.963	0.118	0.000
1982.birth.year	0.991	0.123	0.000
1983.birth.year	0.850	0.125	0.000
1984.birth.year	0.913	0.143	0.000
1985.birth.year	0.829	0.139	0.000
Finland.dummy	-0.124	0.030	0.000
Iceland.dummy	-0.229	0.069	0.001
Norway.dummy	-0.017	0.030	0.577
Sweden.dummy	-0.500	0.031	0.000
.cons	0.182	0.087	
.cons	2.295	0.088	
PseudoR2	0.0586		

Table 14. Output of Logistic Regressions where Independent Variables are the Maximum Parental Education and Dummy Variables Summarizing Both Parents' Education – Rest of Europe

Variable	Coefficient	Std.Error	P-value
maxparentedu.3lvl	0.946	0.015	0.000
d12	0.177	0.039	0.000
d22	0.294	0.021	0.000
d31	-0.956	0.036	0.000
d13	-1.164	0.054	0.000
d23	-0.434	0.050	0.000
d33	-0.465	0.033	0.000
1941.birth.year	0.010	0.073	0.889
1942.birth.year	0.059	0.073	0.417
1943.birth.year	0.034	0.073	0.644
1944.birth.year	0.141	0.071	0.048
1945.birth.year	0.002	0.072	0.974
1946.birth.year	0.171	0.072	0.017
1947.birth.year	0.225	0.070	0.001
1948.birth.year	0.271	0.070	0.000
1949.birth.year	0.282	0.070	0.000
1950.birth.year	0.297	0.069	0.000
1951.birth.year	0.314	0.071	0.000
1952.birth.year	0.375	0.069	0.000
1953.birth.year	0.515	0.070	0.000
1954.birth.year	0.403	0.070	0.000
1955.birth.year	0.374	0.069	0.000
1956.birth.year	0.491	0.068	0.000
1957.birth.year	0.453	0.069	0.000
1958.birth.year	0.558	0.068	0.000
1959.birth.year	0.568	0.068	0.000
1960.birth.year	0.507	0.067	0.000
1961.birth.year	0.594	0.067	0.000
1962.birth.year	0.565	0.066	0.000
1963.birth.year	0.542	0.066	0.000
1964.birth.year	0.587	0.067	0.000
1965.birth.year	0.535	0.067	0.000
1966.birth.year	0.574	0.067	0.000
1967.birth.year	0.613	0.067	0.000
1968.birth.year	0.688	0.068	0.000
1969.birth.year	0.586	0.068	0.000
1970.birth.year	0.655	0.067	0.000
1971.birth.year	0.668	0.069	0.000
1972.birth.year	0.772	0.070	0.000
1973.birth.year	0.762	0.071	0.000
1974.birth.year	0.732	0.071	0.000
1975.birth.year	0.760	0.072	0.000
1976.birth.year	0.807	0.073	0.000
1977.birth.year	0.781	0.072	0.000
1978.birth.year	0.908	0.074	0.000
1979.birth.year	0.716	0.076	0.000
1980.birth.year	0.815	0.076	0.000
1981.birth.year	0.700	0.080	0.000
1982.birth.year	0.608	0.084	0.000
1983.birth.year	0.572	0.092	0.000
1984.birth.year	0.754	0.096	0.000
1985.birth.year	0.601	0.097	0.000
Belgium.dummy	0.518	0.031	0.000
Switzerland.dummy	0.453	0.030	0.000
Germany.dummy	0.356	0.027	0.000
United.Kingdom.dummy	0.291	0.032	0.000
Ireland.dummy	0.419	0.030	0.000
Luxembourg.dummy	-0.037	0.048	0.435
Netherlands.dummy	0.298	0.030	0.000

cons	1.365057	0.059868	
cons	3.366898	0.061142	
Observations	70542		
Pseudo R2	0.0664		

Table 15. Output of Logistic Regressions where Independent Variables are the Maximum Parental Education, Dummy Variables Summarizing Both Parents' Education and Child's Gender – Mediterranean Country Group

Variable	Coefficient	Std.Error	P-value
maxparentedu.3lvl	1.086	0.024	0.000
1941.birth.year	0.083	0.155	0.593
1942.birth.year	0.435	0.149	0.004
1943.birth.year	0.276	0.154	0.073
1944.birth.year	0.184	0.149	0.215
1945.birth.year	0.508	0.143	0.000
1946.birth.year	0.613	0.143	0.000
1947.birth.year	0.565	0.140	0.000
1948.birth.year	0.644	0.139	0.000
1949.birth.year	0.679	0.142	0.000
1950.birth.year	0.559	0.139	0.000
1951.birth.year	0.733	0.144	0.000
1952.birth.year	0.564	0.140	0.000
1953.birth.year	0.833	0.140	0.000
1954.birth.year	0.645	0.143	0.000
1955.birth.year	0.790	0.142	0.000
1956.birth.year	1.081	0.136	0.000
1957.birth.year	1.015	0.137	0.000
1958.birth.year	0.957	0.136	0.000
1959.birth.year	0.997	0.136	0.000
1960.birth.year	0.855	0.133	0.000
1961.birth.year	1.039	0.138	0.000
1962.birth.year	0.969	0.136	0.000
1963.birth.year	1.167	0.135	0.000
1964.birth.year	1.196	0.135	0.000
1965.birth.year	1.194	0.134	0.000
1966.birth.year	1.132	0.134	0.000
1967.birth.year	1.167	0.133	0.000
1968.birth.year	1.178	0.133	0.000
1969.birth.year	1.130	0.133	0.000
1970.birth.year	1.273	0.133	0.000
1971.birth.year	1.304	0.133	0.000
1972.birth.year	1.400	0.131	0.000
1973.birth.year	1.201	0.133	0.000
1974.birth.year	1.149	0.133	0.000
1975.birth.year	1.395	0.132	0.000
1976.birth.year	1.132	0.135	0.000
1977.birth.year	1.403	0.133	0.000
1978.birth.year	1.471	0.137	0.000
1979.birth.year	1.346	0.139	0.000
1980.birth.year	1.461	0.139	0.000
1981.birth.year	1.376	0.144	0.000
1982.birth.year	1.386	0.149	0.000
1983.birth.year	1.171	0.154	0.000
1984.birth.year	1.211	0.164	0.000
1985.birth.year	1.024	0.179	0.000
d12	0.072	0.060	0.234
d22	0.324	0.046	0.000
d31	-1.546	0.059	0.000
d13	-1.609	0.080	0.000
d23	-0.546	0.090	0.000
d33	-0.835	0.056	0.000
gender.fe.1940	-0.641	0.155	0.000
gender.fe.1941	-0.391	0.166	0.019
gender.fe.1942	-0.824	0.156	0.000
gender.fe.1943	-0.568	0.157	0.000
gender.fe.1944	-0.419	0.147	0.004
gender.fe.1945	-0.632	0.139	0.000
gender.fe.1946	-0.518	0.133	0.000

gender.fe.1947	-0.438	0.130	0.001
gender.fe.1948	-0.592	0.129	0.000
gender.fe.1949	-0.431	0.130	0.001
gender.fe.1950	-0.338	0.126	0.007
gender.fe.1951	-0.389	0.133	0.003
gender.fe.1952	-0.165	0.128	0.196
gender.fe.1953	-0.153	0.124	0.217
gender.fe.1954	-0.022	0.128	0.864
gender.fe.1955	-0.231	0.129	0.072
gender.fe.1956	-0.398	0.121	0.001
gender.fe.1957	-0.323	0.121	0.007
gender.fe.1958	-0.127	0.121	0.297
gender.fe.1959	-0.225	0.118	0.057
gender.fe.1960	0.111	0.111	0.315
gender.fe.1961	-0.041	0.118	0.728
gender.fe.1962	-0.029	0.116	0.800
gender.fe.1963	-0.092	0.116	0.428
gender.fe.1964	-0.174	0.115	0.130
gender.fe.1965	0.004	0.111	0.968
gender.fe.1966	0.118	0.114	0.300
gender.fe.1967	0.085	0.112	0.446
gender.fe.1968	0.056	0.111	0.616
gender.fe.1969	0.268	0.113	0.017
gender.fe.1970	0.053	0.110	0.632
gender.fe.1971	0.020	0.112	0.856
gender.fe.1972	-0.022	0.110	0.839
gender.fe.1973	0.361	0.113	0.001
gender.fe.1974	0.359	0.113	0.001
gender.fe.1975	0.172	0.111	0.122
gender.fe.1976	0.479	0.117	0.000
gender.fe.1977	0.187	0.111	0.092
gender.fe.1978	0.287	0.120	0.017
gender.fe.1979	0.347	0.128	0.007
gender.fe.1980	0.256	0.124	0.040
gender.fe.1981	0.236	0.138	0.088
gender.fe.1982	0.315	0.149	0.035
gender.fe.1983	0.468	0.155	0.003
gender.fe.1984	0.515	0.179	0.004
gender.fe.1985	0.459	0.205	0.025
Cyprus.dummy	1.094	0.075	0.000
Spain.dummy	0.234	0.071	0.001
France.dummy	0.909	0.070	0.000
Greece.dummy	0.599	0.071	0.000
Isreal.dummy	1.190	0.072	0.000
Italy.dummy	0.297	0.083	0.000
Portugal.dummy	-0.501	0.072	0.000
Turkey.dummy	-1.001	0.080	0.000
cons	2.428	0.128	
cons	4.205	0.129	
Observations	47264		
Pseudo	R2	0.1537	

Table 16. Output of Logistic Regressions where Independent Variables are the Maximum Parental Education, Dummy Variables Summarizing Both Parents' Education and Child's Gender – Post-Socialist Country Group

Variable	Coefficient	Std.Error	P-value
maxparentedu.3lvl	0.952	0.016	0.000
1941.birth.year	-0.206	0.118	0.079
1942.birth.year	0.063	0.120	0.602
1943.birth.year	0.118	0.120	0.326
1944.birth.year	0.280	0.121	0.021
1945.birth.year	0.139	0.118	0.239
1946.birth.year	0.158	0.115	0.169
1947.birth.year	0.268	0.112	0.017
1948.birth.year	0.318	0.110	0.004
1949.birth.year	0.242	0.108	0.025
1950.birth.year	0.249	0.106	0.019
1951.birth.year	0.312	0.109	0.004
1952.birth.year	0.229	0.109	0.035
1953.birth.year	0.328	0.108	0.002
1954.birth.year	0.368	0.108	0.001
1955.birth.year	0.276	0.106	0.010
1956.birth.year	0.315	0.108	0.003
1957.birth.year	0.330	0.108	0.002
1958.birth.year	0.291	0.107	0.007
1959.birth.year	0.320	0.110	0.004
1960.birth.year	0.335	0.107	0.002
1961.birth.year	0.301	0.110	0.006
1962.birth.year	0.275	0.109	0.012
1963.birth.year	0.498	0.110	0.000
1964.birth.year	0.307	0.108	0.005
1965.birth.year	0.356	0.109	0.001
1966.birth.year	0.195	0.111	0.079
1967.birth.year	0.199	0.111	0.074
1968.birth.year	0.129	0.110	0.242
1969.birth.year	0.175	0.113	0.120
1970.birth.year	0.196	0.109	0.073
1971.birth.year	0.255	0.111	0.021
1972.birth.year	0.215	0.110	0.052
1973.birth.year	0.091	0.110	0.410
1974.birth.year	0.212	0.109	0.052
1975.birth.year	0.288	0.110	0.009
1976.birth.year	0.190	0.109	0.083
1977.birth.year	0.148	0.111	0.181
1978.birth.year	0.186	0.114	0.102
1979.birth.year	0.255	0.114	0.025
1980.birth.year	0.258	0.112	0.021
1981.birth.year	0.096	0.117	0.411
1982.birth.year	0.238	0.122	0.051
1983.birth.year	0.338	0.122	0.006
1984.birth.year	0.263	0.126	0.037
1985.birth.year	0.171	0.139	0.219
d12	-0.006	0.037	0.880
d22	0.409	0.021	0.000
d31	-1.773	0.046	0.000
d13	-1.287	0.064	0.000
d23	-0.065	0.050	0.194
d33	-0.079	0.037	0.033
gender.fe.1940	-0.545	0.107	0.000
gender.fe.1941	-0.341	0.109	0.002
gender.fe.1942	-0.320	0.112	0.004
gender.fe.1943	-0.414	0.113	0.000
gender.fe.1944	-0.508	0.114	0.000
gender.fe.1945	-0.135	0.112	0.228
gender.fe.1946	-0.084	0.104	0.418

gender.fe.1947	-0.142	0.099	0.153
gender.fe.1948	-0.163	0.096	0.089
gender.fe.1949	-0.016	0.094	0.867
gender.fe.1950	-0.071	0.090	0.426
gender.fe.1951	-0.160	0.095	0.090
gender.fe.1952	0.093	0.093	0.317
gender.fe.1953	-0.094	0.094	0.316
gender.fe.1954	0.095	0.093	0.310
gender.fe.1955	0.211	0.091	0.020
gender.fe.1956	0.133	0.093	0.154
gender.fe.1957	0.189	0.093	0.041
gender.fe.1958	0.181	0.092	0.048
gender.fe.1959	0.232	0.096	0.016
gender.fe.1960	0.258	0.092	0.005
gender.fe.1961	0.258	0.099	0.009
gender.fe.1962	0.306	0.097	0.002
gender.fe.1963	-0.036	0.100	0.720
gender.fe.1964	0.420	0.097	0.000
gender.fe.1965	0.284	0.098	0.004
gender.fe.1966	0.317	0.100	0.002
gender.fe.1967	0.425	0.101	0.000
gender.fe.1968	0.419	0.098	0.000
gender.fe.1969	0.287	0.102	0.005
gender.fe.1970	0.304	0.096	0.002
gender.fe.1971	0.115	0.099	0.246
gender.fe.1972	0.263	0.098	0.007
gender.fe.1973	0.401	0.099	0.000
gender.fe.1974	0.151	0.097	0.118
gender.fe.1975	0.157	0.099	0.111
gender.fe.1976	0.349	0.098	0.000
gender.fe.1977	0.340	0.102	0.001
gender.fe.1978	0.303	0.105	0.004
gender.fe.1979	0.273	0.105	0.010
gender.fe.1980	0.382	0.105	0.000
gender.fe.1981	0.467	0.115	0.000
gender.fe.1982	0.356	0.123	0.004
gender.fe.1983	0.317	0.125	0.011
gender.fe.1984	0.490	0.132	0.000
gender.fe.1985	0.682	0.154	0.000
Czech.Rep.dummy	-0.318	0.033	0.000
Estonia.dummy	0.507	0.035	0.000
Croatia.dummy	0.059	0.049	0.229
Hungary.dummy	-0.203	0.035	0.000
Lithuania.dummy	0.595	0.048	0.000
Latvia.dummy	0.209	0.059	0.000
Poland.dummy	-0.231	0.034	0.000
Romania.dummy	-0.591	0.058	0.000
Russia.dummy	1.616	0.038	0.000
Slovenia.dummy	0.024	0.036	0.505
Slovakia.dummyy	-0.031	0.035	0.384
Ukraine.dummy	1.523	0.037	0.000
Kosovo.dummy	-0.942	0.070	0.000
cons	0.356	0.088	
cons	3.410	0.089	
Observations	74367		
PseudoR2	0.1285		

Table 17. Output of Logistic Regressions where Independent Variables are the Maximum Parental Education, Dummy Variables Summarizing Both Parents' Education and Child's Gender – Nordic Country Group

Variable	Coefficient	Std.Error	P-value
maxparentedu.3lvl	0.697	0.022	0.000
1941.birth.year	-0.047	0.155	0.763
1942.birth.year	0.127	0.153	0.408
1943.birth.year	0.092	0.147	0.528
1944.birth.year	0.201	0.145	0.167
1945.birth.year	0.285	0.141	0.044
1946.birth.year	0.361	0.143	0.012
1947.birth.year	0.531	0.144	0.000
1948.birth.year	0.259	0.143	0.069
1949.birth.year	0.709	0.142	0.000
1950.birth.year	0.498	0.143	0.000
1951.birth.year	0.680	0.144	0.000
1952.birth.year	0.527	0.144	0.000
1953.birth.year	0.520	0.144	0.000
1954.birth.year	0.660	0.146	0.000
1955.birth.year	0.623	0.145	0.000
1956.birth.year	0.746	0.144	0.000
1957.birth.year	0.535	0.144	0.000
1958.birth.year	0.614	0.144	0.000
1959.birth.year	0.818	0.143	0.000
1960.birth.year	0.562	0.143	0.000
1961.birth.year	0.562	0.142	0.000
1962.birth.year	0.711	0.142	0.000
1963.birth.year	0.664	0.143	0.000
1964.birth.year	0.573	0.142	0.000
1965.birth.year	0.757	0.139	0.000
1966.birth.year	0.733	0.140	0.000
1967.birth.year	0.845	0.142	0.000
1968.birth.year	0.844	0.142	0.000
1969.birth.year	0.790	0.144	0.000
1970.birth.year	0.833	0.147	0.000
1971.birth.year	0.880	0.144	0.000
1972.birth.year	0.781	0.144	0.000
1973.birth.year	0.938	0.150	0.000
1974.birth.year	1.039	0.145	0.000
1975.birth.year	0.908	0.145	0.000
1976.birth.year	0.762	0.148	0.000
1977.birth.year	0.912	0.149	0.000
1978.birth.year	0.879	0.161	0.000
1979.birth.year	0.881	0.157	0.000
1980.birth.year	0.817	0.161	0.000
1981.birth.year	0.706	0.161	0.000
1982.birth.year	0.669	0.168	0.000
1983.birth.year	0.723	0.171	0.000
1984.birth.year	0.651	0.197	0.001
1985.birth.year	0.556	0.188	0.003
d12	-0.215	0.046	0.000
d22	0.167	0.036	0.000
d31	-0.448	0.058	0.000
d13	-0.563	0.078	0.000
d23	-0.172	0.066	0.010
d33	-0.285	0.045	0.000
gender.fe.1940	-0.035	0.158	0.827
gender.fe.1941	-0.257	0.153	0.092
gender.fe.1942	-0.002	0.151	0.990
gender.fe.1943	-0.038	0.137	0.780
gender.fe.1944	-0.110	0.138	0.424
gender.fe.1945	-0.029	0.126	0.820
gender.fe.1946	-0.195	0.124	0.117

gender.fe.1947	-0.138	0.125	0.271
gender.fe.1948	0.486	0.131	0.000
gender.fe.1949	-0.136	0.127	0.282
gender.fe.1950	0.049	0.131	0.708
gender.fe.1951	0.037	0.130	0.775
gender.fe.1952	0.232	0.128	0.070
gender.fe.1953	0.514	0.134	0.000
gender.fe.1954	0.332	0.132	0.012
gender.fe.1955	0.289	0.130	0.026
gender.fe.1956	0.237	0.131	0.071
gender.fe.1957	0.561	0.131	0.000
gender.fe.1958	0.527	0.127	0.000
gender.fe.1959	0.317	0.131	0.016
gender.fe.1960	0.621	0.131	0.000
gender.fe.1961	0.317	0.127	0.013
gender.fe.1962	0.370	0.127	0.003
gender.fe.1963	0.605	0.128	0.000
gender.fe.1964	0.537	0.124	0.000
gender.fe.1965	0.563	0.121	0.000
gender.fe.1966	0.688	0.125	0.000
gender.fe.1967	0.532	0.129	0.000
gender.fe.1968	0.428	0.130	0.001
gender.fe.1969	0.507	0.132	0.000
gender.fe.1970	0.501	0.137	0.000
gender.fe.1971	0.430	0.134	0.001
gender.fe.1972	0.630	0.133	0.000
gender.fe.1973	0.602	0.146	0.000
gender.fe.1974	0.279	0.138	0.043
gender.fe.1975	0.413	0.134	0.002
gender.fe.1976	0.595	0.138	0.000
gender.fe.1977	0.596	0.145	0.000
gender.fe.1978	0.558	0.161	0.001
gender.fe.1979	0.522	0.163	0.001
gender.fe.1980	0.623	0.175	0.000
gender.fe.1981	0.544	0.175	0.002
gender.fe.1982	0.692	0.191	0.000
gender.fe.1983	0.256	0.195	0.189
gender.fe.1984	0.537	0.240	0.025
gender.fe.1985	0.594	0.230	0.010
Finland.dummy	-0.123	0.030	0.000
Iceland.dummy	-0.237	0.069	0.001
Norway.dummy	-0.007	0.031	0.831
Sweden.dummy	-0.498	0.031	0.000
cons	0.174264	0.117701	
cons	2.306143	0.11845	
Observations	35951		
PseudoR2	0.0647		

Table 18. Output of Logistic Regressions where Independent Variables are the Maximum Parental Education, Dummy Variables Summarizing Both Parents' Education and Child's Gender – Rest of Europe

Variable	Coefficient	Std.Error	P-value
maxparentedu.3lvl	0.954	0.015	0.000
1941.birth.year	-0.047	0.102	0.646
1942.birth.year	0.014	0.103	0.891
1943.birth.year	-0.056	0.101	0.580
1944.birth.year	0.129	0.101	0.202
1945.birth.year	-0.126	0.102	0.216
1946.birth.year	0.026	0.102	0.798
1947.birth.year	0.037	0.098	0.710
1948.birth.year	0.118	0.098	0.232
1949.birth.year	0.077	0.100	0.441
1950.birth.year	0.034	0.096	0.725
1951.birth.year	0.102	0.100	0.306
1952.birth.year	0.065	0.098	0.508
1953.birth.year	0.234	0.100	0.019
1954.birth.year	0.191	0.098	0.051
1955.birth.year	0.109	0.098	0.268
1956.birth.year	0.218	0.097	0.025
1957.birth.year	0.151	0.097	0.120
1958.birth.year	0.296	0.097	0.002
1959.birth.year	0.304	0.096	0.002
1960.birth.year	0.177	0.095	0.063
1961.birth.year	0.381	0.095	0.000
1962.birth.year	0.201	0.094	0.032
1963.birth.year	0.126	0.095	0.183
1964.birth.year	0.255	0.095	0.007
1965.birth.year	0.231	0.095	0.015
1966.birth.year	0.219	0.095	0.021
1967.birth.year	0.248	0.095	0.009
1968.birth.year	0.245	0.097	0.012
1969.birth.year	0.190	0.097	0.050
1970.birth.year	0.272	0.095	0.004
1971.birth.year	0.226	0.097	0.020
1972.birth.year	0.331	0.099	0.001
1973.birth.year	0.358	0.102	0.000
1974.birth.year	0.388	0.103	0.000
1975.birth.year	0.322	0.102	0.002
1976.birth.year	0.308	0.103	0.003
1977.birth.year	0.278	0.102	0.006
1978.birth.year	0.437	0.106	0.000
1979.birth.year	0.223	0.107	0.037
1980.birth.year	0.296	0.108	0.006
1981.birth.year	0.165	0.115	0.153
1982.birth.year	0.101	0.121	0.401
1983.birth.year	0.054	0.132	0.684
1984.birth.year	0.287	0.141	0.041
1985.birth.year	0.118	0.136	0.385
d12	0.186	0.039	0.000
d22	0.297	0.022	0.000
d31	-0.957	0.036	0.000
d13	-1.181	0.054	0.000
d23	-0.444	0.050	0.000
d33	-0.467	0.033	0.000
gender.fe.1940	-0.887	0.103	0.000
gender.fe.1941	-0.737	0.104	0.000
gender.fe.1942	-0.752	0.105	0.000
gender.fe.1943	-0.685	0.103	0.000
gender.fe.1944	-0.790	0.099	0.000
gender.fe.1945	-0.594	0.102	0.000
gender.fe.1946	-0.528	0.100	0.000

gender.fe.1947	-0.475	0.096	0.000
gender.fe.1948	-0.528	0.095	0.000
gender.fe.1949	-0.426	0.097	0.000
gender.fe.1950	-0.324	0.091	0.000
gender.fe.1951	-0.412	0.097	0.000
gender.fe.1952	-0.225	0.092	0.015
gender.fe.1953	-0.278	0.096	0.004
gender.fe.1954	-0.423	0.094	0.000
gender.fe.1955	-0.306	0.093	0.001
gender.fe.1956	-0.288	0.090	0.001
gender.fe.1957	-0.243	0.093	0.009
gender.fe.1958	-0.312	0.090	0.001
gender.fe.1959	-0.310	0.089	0.000
gender.fe.1960	-0.177	0.085	0.037
gender.fe.1961	-0.401	0.085	0.000
gender.fe.1962	-0.120	0.084	0.154
gender.fe.1963	-0.021	0.085	0.804
gender.fe.1964	-0.179	0.086	0.037
gender.fe.1965	-0.230	0.085	0.007
gender.fe.1966	-0.132	0.085	0.122
gender.fe.1967	-0.117	0.087	0.175
gender.fe.1968	0.030	0.089	0.738
gender.fe.1969	-0.058	0.089	0.516
gender.fe.1970	-0.084	0.086	0.329
gender.fe.1971	0.028	0.092	0.757
gender.fe.1972	0.027	0.094	0.777
gender.fe.1973	-0.043	0.099	0.667
gender.fe.1974	-0.149	0.099	0.133
gender.fe.1975	0.020	0.100	0.845
gender.fe.1976	0.136	0.102	0.185
gender.fe.1977	0.144	0.100	0.152
gender.fe.1978	0.082	0.107	0.442
gender.fe.1979	0.127	0.111	0.253
gender.fe.1980	0.173	0.112	0.123
gender.fe.1981	0.195	0.122	0.111
gender.fe.1982	0.144	0.132	0.275
gender.fe.1983	0.166	0.152	0.275
gender.fe.1984	0.070	0.163	0.670
gender.fe.1985	0.106	0.163	0.518
Belgium.dummy	0.510	0.031	0.000
Switzerland.dummy	0.453	0.030	0.000
Germany.dummy	0.346	0.027	0.000
UK.dummy	0.291	0.032	0.000
Ireland.dummy	0.421	0.030	0.000
Luxembourg.dummy	-0.056	0.048	0.244
Netherlands.dummy	0.298	0.031	0.000
cons	0.942	0.077	
cons	2.957	0.078	
Observations	70542		
Pseudo R2	0.0704		

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