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HOME PRODUCTION, LABOR TAXATION AND TRADE ACCOUNT

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ABSTRACT: The two-country growth model developed in this paper incorporates home production and distinguishes between a market sector producing services that can also be home-produced and a market sector producing goods without home-produced substitutes. This distinction coincides in the model with the distinction between the sector producing internationally tradable goods and the sector producing nontradables. Hence, differentials in labor tax rates across countries, which determine differences in the allocation of households' time between market activities and home activities, influence also the mix of tradable and nontradable goods that characterizes the market output of each country, thus affecting their bilateral trade balance.

KEY WORDS: Market time, employment rate, nontradable goods, two-country model, endogenous growth.

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1 INTRODUCTION

There are four stylized facts that emerge among others when comparing the US economy and the Euro area in the last 25 years: i) market work is much higher in the US; ii) the higher employment rate characterizing the US relative to the Euro area is entirely due to higher US employment in the services sector; iii) labor tax rates are higher in the Euro area, and iv) the US has a structural trade deficit, while the Euro area as a whole runs persistent trade surpluses (and the US have a persistent bilateral trade deficit with the Euro area). The links between the former three facts have been recently analyzed by a few papers (Davis and Henrekson, 2004; Olovsson, 2004; Rogerson, 2005), while the links connecting the former three facts to the latter have not yet been recognized and modeled. The aim of this paper is exactly to provide an original two-country growth model that may help at shedding light on the possible relations linking these four facts.

The setup developed in this paper extends the dynamic general equilibrium models that incorporate home production (Benhabib et al., 1991; McGratten et al., 1997; Parente et al., 2000) along two dimensions, namely by distinguishing two market sectors and by integrating two similar economies that differ only with respect to tax rates (labor income taxes and possibly capital income taxes). The distinction between a market sector producing services that can also be produced in the nonmarket sector of the economy and a market sector producing goods that have no home-produced substitutes coincides in the model with the distinction between the sector producing internationally tradable goods and the sector producing nontradables. In this way, differentials in labor tax rates across countries, which determine differences in the allocation of households' time between market activities and home activities, influence also the mix of tradable and nontradable goods that characterizes the market output of each country, thus affecting their bilateral trade balance.

The greater time spent in market work by Americans relative to Europeans is probably the most significant measure of the different performance of the labor market on the two sides of the Atlantic. Indeed, in 2004 the annual hours per person spent in market work were approximately one third higher in the US than in the three major countries of the Euro area (see table 1). However, this large difference in market work does not imply that total work time is much higher in the US than in the Euro area: the available evidence shows that Europeans tend to devote a larger fraction of their time to unpaid work at home, thus self-producing part of those services that Americans buy on the market (Davis and Henrekson, 2004; Olovsson, 2004; Freeman and Schettkat, 2005; Ragan, 2005; Rogerson, 2005; Burda et al., 2006).[1] Consistently with this evidence, "the relevant question is not why do Europeans work so little (…) but why do they choose to work so much at home." (Ragan, 2005, p.4).

Table 1 Countries differences in market work time per 15-64 years olds

(annual hours worked per person[a])

Year	France	Germany[b]	Italy	United States
1990	979	1004	871	1344
2004	905	934	910	1299

[a] Employed/population*annual hours worked per employee.
[b] German figures on hours worked are for West Germany.
Source: Freeman and Schettkat, 2005.

This tendency is related to the fact that the higher employment rate characterizing the US relatively to the Euro area (see table 2) is entirely due to the higher US employment in services. As the European Commission points out with reference to the late 1990s, "The main

[1] Freeman and Schettkat (2005) emphasize that data from the Multinational Time Use Study show that in the early 1990s total work (market work plus time spent in household production) was approximately the same for US and Europeans adults, although the amount of market work was higher in the US. According to Burda et al. (2006), international comparisons of time-use diaries suggest that total work in the US currently exceeds that in Germany and Italy, although the time devoted to home production is higher in Germany and Italy than in the US.

difference in employment between the US and Europe is not in agriculture or manufacturing, where employment rates are broadly similar, but in services, where the overall gap in employment rates is 14% points." (European Commission, 1999, p. 12).[2]

A common explanation linking the difference in market work between US and the Euro area to the gap between European and US employment shares in services rests on the higher tax rates on labor income to which the European households are subject.[3] Davis and Henrekson (2004), Olovsson (2004) and Rogerson (2005) report evidence showing that persistently high tax rates depress labor supply and twist the mix of market employment and production away from services for which there are close nonmarket substitutes (preparing meals, cleaning and laundry, child and elderly care, shopping, repairs and maintenance…). As a matter of fact, market sectors producing goods that cannot be home produced (e.g.,

[2] In 1997, the share of the working-age population (15-64 years) employed in industry was the same in the USA and in the EU (17.7), while the share employed in services was 54.5 in the US and 39.7 in the EU. On the recent evolution of the gap between European and US employment shares in the aggregate services sector see D'Agostino et al. (2006).

[3] According to Prescott (2004), differences in the marginal tax rate on labor income can explain almost entirely the difference in worked hours between French, Germans and Italians on one side and Americans on the other side. He estimates that the marginal labor income tax rates in the period 1993-96 were O.59 in Germany and France, 0.64 in Italy and 0.40 in the US. Critics point out that the increase in tax rates occurred in Continental Europe in the 1970s and in the 1980s, while the decline in worked time continued also during the 1990s (see Alesina et al., 2005). Furthermore, the available micro evidence shows that the role of the difference in tax rates in generating the large differential in market work between the European countries and the United States cannot be inferred from the individual labor supply elasticities alone (see Davis and Henrekson, 2004; Alesina et al., 2005; Ragan, 2005). However, one should also consider that countries with higher tax rates tend to have more generous tax-funded public programs and government transfers that weaken labor supply incentives, although one may expect that market work increases when a larger share of public expenditures is devoted to the provision of services that are close substitutes for home produced services like child or elderly care (see Ragan, 2005).

manufacturing goods) do not appear sensitive to personal tax rates (see Davis and Henrekson, 2004).

Table 2 Countries differences in employment rate

(Employed/working-age population[a])

Year	France	Germany	Italy	United States
1998	0.594	0.641	0.508	0.738
2004	0.628	0.655	0.574	0.712

[a] 15-64 years olds.
Source: OECD.

An unexplored implication of the structural differences brought about by persistent differentials in labor tax rates concerns international trade. It is not surprising, indeed, that policies and institutions determining long-term differences across countries in the time devoted to market activities and in the composition of market output may also have systematic effects on their trade account. In particular, one should consider that in general those market services which have close nonmarket substitutes are not internationally tradable, while it is typically true the opposite for those goods which are combined with labor to produce both market services and their home-produced substitutes. Moreover, the demand for these tradable goods is likely to be higher in a country with lower labor taxes, as a consequence of the fact that in such a country the market production of services is greater and the home production of services is more goods intense (and less labor intense) than in a country where labor is taxed more heavily. One can also argue that the higher demand for tradable goods characterizing a country with lower labor taxes is not matched by the presence of more favorable conditions for the production of these goods in such a country rather than in a country with higher labor taxes, since the additional labor supply existing in a country with lower labor taxes tends to be absorbed by the higher demand for labor coming from the market sector producing (internationally) nontradable services. Therefore, one should expect that in a two-country economy--where countries differ only with respect to their tax rates--the country with lower labor taxes tends to exhibit a trade deficit.

The above conclusion, which can be derived from the two-country model presented here, is consistent with the persistent bilateral trade deficit that the US have with the Euro area (see table 3). Although one must obviously allow for the other factors influencing the bilateral trade balance between the US and the Euro area, which include the trade relations that both have with the rest of the world, this conclusion captures the structural component of the US trade deficit due to fact that the nontradable services represent a larger share of market output in the US than in most other advanced countries.[4]

The paper is organized as follows: section 2 presents the model; section 3 characterizes the equilibrium trajectories of the two-country economy when one country has a higher labor tax rate than the other; section 4 concludes.

Table 3 Eura area trade balance with the US

(billions of ECU-Euro)

1996	1998	2000	2002	2004
4.64	14.72	30.23	58.29	59.71

Source: Eurostat.

2 THE MODEL

In the two-country economy under consideration, there are firms which operate in the market sector producing an internationally tradable good and firms which operate in the market sector producing an internationally nontradable service. Moreover, there are

[4] Mann (2004) emphasizes that technological factors that make services more tradable internationally should result in an improvement of the US structural trade deficit.

households which may consume both the market-produced service and a home-produced service, and national governments which tax labor and capital for making transfers to the households. The two countries differ with respect to the tax rates imposed by their respective government. The tradable good is used as capital in both market sectors and in the home production process. Capital is internationally mobile, while labor is internationally immobile. However, both factors can freely move across sectors. All markets are perfectly competitive. Time is discrete and the time horizon is infinite. There is no source of random disturbances and agents' expectations are rational (in the sense that they are consistent with the true processes followed by the relevant variables), thus implying perfect foresight.

Firms producing the (internationally) nontradable good

In each country i, i=us,eu, there is a large number (normalized to be one) of firms producing the consumer service. They are identical and in each period t they produce the consumer service N_{it} according to the following technology:

$$N_{it} = K_{iNt}^{1-\beta} L_{iNt}^{\beta}, \; 0 < \beta < 1, \tag{1}$$

where K_{iNt} and L_{iNt} are, respectively, the capital stock and the labor input used in country i to produce the (internationally) nontradable market service N_{it}. In each t, firms employ labor and rent capital in order to maximize their profits π_{iNt}, that are given by

$$\pi_{iNt}=N_{it}-W_{it}L_{iNt}-R_{it}K_{iNt}, \tag{2}$$

where W_{it} and R_{it} are, respectively, the wage rate and the rental rate on capital in country i. Notice that N_{it} is the numéraire of country i and its price is normalized to be one. It is also assumed that N_{it} is not storable and must be immediately consumed.[5]

Since capital is internationally mobile, the following non-arbitrage condition must hold in each t:

[5] Typically, consumer services are consumed while they are produced.

$$R_{it}=E_{it}R_{jt},\ i\neq j, \tag{3}$$

where E_{it} is the i-numéraire price of the j numéraire, namely the price in units of the nontradable good produced in i of one unit of the nontradable good produced in j.

Firms producing the (internationally) tradable good

In each country i, there is a large number (normalized to be one) of firms producing the (internationally) tradable good. They are identical and in each period t they produce T_{it} according to the following technology:

$$T_{it} = A_{it}\, K_{iTt}^{1-\alpha}\, L_{iTt}^{\alpha},\ 0<\alpha<1, \tag{4}$$

where K_{iTt} and L_{iTt} are, respectively, the capital stock and the labor input used in country i to produce the (internationally) tradable good T_{it}, and A_{it} is a variable measuring the state of technology of the firms operating in the market sector of country i which produces the (internationally) tradable good T_{it}. It is assumed that A_{it} is a positive function of the capital installed in the sector of i which produces T_{it}: $A_{it} = K_{iTt}^{\alpha}$.[6] This assumption combines the idea that learning-by-doing works through each firm's capital investment and the idea that knowledge and productivity gains spill over instantly across all firms (see Barro and Sala-i-Martin, 1995). Therefore, in accordance with Frankel (1962), it is supposed that although A_{it} is endogenous to the economy, each firm takes it as given, since a single firm's decisions have only a negligible impact on the aggregate stock of capital of the tradable sector.[7] Note that I am assuming that the (internationally) tradable sector is subject to endogenous technological progress (it is a "progressive" industry), while the nontradable sector is not subject to technological progress (it is a technologically "stagnant" industry).[8] The stagnant industry

[6] Consistently with this formal set-up, one can interpret technological progress as labor augmenting.

[7] This amounts to say that technological progress is endogenous to the economy, although it is an unintended by-products of firms' capital investment rather than the result of purposive R&D efforts.

[8] The "progressive" sector can be identified with the manufacturing sector, with the possible inclusion of some

uses an input (capital) that is produced by the progressive industry, thus benefiting indirectly by the possible improvements in total factor productivity (TFP) achieved in the latter. Finally, consistently with that evidence showing that technology/knowledge spillovers are primarily intranational (see e.g. Branstetter, 1996), I maintain that the state of technology of the firms producing the tradable good in country i depends only the capital installed in the tradable-good sector of country i (no international technology/knowledge spillovers).

In each period t, the firms producing T_{it} hire labor and rent capital in order to maximize their profits π_{iTt}, that are given by

$$\pi_{iTt}=P_{it}T_{it}-W_{it}L_{iTt}-R_{it}K_{iTt}, \tag{5}$$

where P_{it} is the price of the tradable good (in units of N_{it}) in country i.

The law of one price implies:

$$P_{it}=E_{it}P_{jt}, \quad i\neq j. \tag{6}$$

Households

Households are infinitely lived. Their large number living in country i is normalized to be one. The period utility function of the representative household of country i is given by

$$u_{it} = [\mu\ln(N_{it}) + (1-\mu)\ln(H_{it})],\ 0 < \mu < 1, \tag{7}$$

where H_{it} is the amount of consumer service produced at home for self-consumption. This nonmarket service is produced according to the following technology:

$$H_{it} = K_{iHt}^{1-\gamma} L_{iHt}^{\gamma},\ 0 < \gamma < 1, \tag{8}$$

where K_{iHt} and L_{iHt} are, respectively, the amount of capital and the time that households devote to home production. Note that consumer durables are interpreted as home capital:

service branches (Transport, Communications, Financial services), which have experienced radical changes in their production processes because of the massive introduction of information and communication technologies (ICT). One can include in the "stagnant" sector the remaining branches of services. A distinction along similar lines was proposed (but at the early stage of the ICT revolution) by Baumol (1967) and Baumol et al. (1985).

consistently with this interpretation, the (internationally) tradable sector produce only capital goods and the tradable good can be interpreted as a composite good representing those market-produced goods for which there is no home-produced substitute.

Given (3) and (6), the period budget constraint of the representative household can be written as:

$$K_{it+1}P_{it}+N_{it}\leq(K_{it}-K_{iHt})(1-\tau_{iK})R_{it}+(L-L_{iHt})(1-\tau_{iL})W_{it}+G_{it},\ 0\leq\tau_{iK}<1,\ 0\leq\tau_{iL}<1,\ K_{i0}\text{ given,} \quad (9)$$

where K_{it} is the total amount of capital held in t by the representative household of country i, L is the fixed amount of time endowed to each household, G_{it} are the fiscal transfers that each household receive in t from its national government, τ_{iK} is the tax rate on capital income in country i (all capital income—no matters whether generated in the home country or abroad--is subject in country i to the same tax rate decided by the domestic authorities) and τ_{iL} is the tax rate on labor income in i. Note that for simplicity the households' total time (market work plus time devoted to home activities) is assumed to be equal in the two countries. Again for simplicity it is assumed full capital depreciation.

In each t, the representative household must choose the sequences $\{K_{in+1}\}_{n=t}^{\infty}$, $\{N_{in}\}_{n=t}^{\infty}$, $\{K_{iHn}\}_{n=t}^{\infty}$ and $\{L_{iHn}\}_{n=t}^{\infty}$ in order to maximize its discounted sequence of utility:

$$\sum_{n=t}^{\infty}\theta^{n-t}u_{in} \text{ subject to (9), } 0<\theta<1, \quad (10)$$

where θ is a time-preference parameter.

Governments

Each government balances its budget in each period:

$$G_{it}=(K_{it}-K_{iHt})R_{it}\tau_{iK}+(L-L_{iHt})W_{it}\tau_{iL}. \quad (11)$$

Markets equilibrium

Equilibrium in the market for the (internationally) nontradable good produced in country i requires

$$N_{it}^{s} = N_{it}^{d}. \tag{12}$$

Equilibrium in the labor market of country i requires

$$L\text{-}L_{iHt}=L_{iTt}+L_{iNt}. \tag{13}$$

Equilibrium in the world market for the (internationally) tradable good requires

$$T_{ust}+T_{eut}=K_{ust+1}+K_{eut+1}. \tag{14}$$

Equilibrium in the world market for capital requires

$$K_{ust}\text{-}K_{usHt}+K_{eut}\text{-}K_{euHt}= K_{usTt}+K_{usNt}+K_{euTt} +K_{euNt}. \tag{15}$$

3 CHARACTERIZATION OF AN EQUILIBRIUM PATH

Given (3), (6), (12), (13) and the agents' optimality conditions (A1)-(A6) (see the Appendix), the following equations must hold along an equilibrium path:

$$L_{iTt}=L_{jTt}, \quad i\neq j, \tag{16}$$

$$L_{iHt} = \frac{(1-\mu)\gamma(L - L_{iTt})}{(1-\mu)\gamma + \beta\mu(1-\tau_{iL})}, \tag{17}$$

$$L_{iNt} = \frac{\beta\mu(1-\tau_{iL})(L - L_{iTt})}{(1-\mu)\gamma + \beta\mu(1-\tau_{iL})}, \tag{18}$$

$$K_{iNt} = \frac{K_{iHt}(1-\beta)\mu(1-\tau_{iK})}{(1-\mu)(1-\gamma)}, \tag{19}$$

$$K_{iTt} = \frac{K_{iHt}L_{iTt}[(1-\mu)\gamma + \beta\mu(1-\tau_{iL})](1-\alpha)(1-\tau_{iK})}{\alpha(1-\mu)(1-\gamma)(1-\tau_{iL})(L - L_{iTt})}, \tag{20}$$

$$E_{it} = \left(\frac{L_{iNt}K_{jNt}}{L_{jNt}K_{iNt}}\right)^{\beta}, \quad i\neq j, \tag{21}$$

$$W_{it} = \beta\left(\frac{K_{iNt}}{L_{iNt}}\right)^{1-\beta}, \tag{22}$$

$$R_{it} = (1-\beta)\left(\frac{L_{iNt}}{K_{iNt}}\right)^{\beta}, \tag{23}$$

$$P_{it} = \frac{(1-\beta)}{(1-\alpha)L_{iTt}^{\alpha}}\left(\frac{L_{iNt}}{K_{iNt}}\right)^{\beta}, \tag{24}$$

$$\rho_{iHt} = \theta(1-\alpha)(1-\tau_{iK})L_{iTt}^{\alpha} - 1, \;\; \rho_{iHt} \equiv \frac{K_{iHt+1} - K_{iHt}}{K_{iHt}}. \tag{25}$$

Note in (16) that the fraction of the households' time devoted to the production of the (internationally) tradable good is the same in the two countries. This is due to the law of one price operating in the world market for the tradable good and to the equalization of returns in the world capital market, combined with the fact that the additional labor supply existing in a country with lower labor taxes tends to be absorbed by the higher demand for labor coming from the market sector producing (internationally) nontradable services.

Given (16), one can easily check in (17) and (18) that the country with the higher tax rate on labor income devotes a larger share of the households' time to home production and a smaller share of the households' time to the production of the market service, thus allocating less time to market activities.

One can also see by inspecting (19) and (20) that—other things being equal--the ratio between the capital installed in the tradable sector (K_{iTt}) and the total capital installed in the country ($K_{iTt}+K_{iNt}+K_{iHt}$) is higher when labor income is taxed more heavily.

Finally, (25) shows--together with (16), (19) and (20)--that the capital installed in the country taxing the capital income less heavily tends to grow faster. Indeed, τ_{iK} influences not only the pace at which the households located in i accumulate productive assets but also the rate at which the capital installed in i grows. This is because the demand for the nontradable good and the production of the home-produced good tend to increase together with the households' income. Thus, the capital used by the firms operating in the nontradable sector and the durables used in home production grow faster in the country where τ_{iK} is lower. The same is true for the capital used in the tradable sector, since the optimizing behavior of firms operating in the same country and thus facing the same costs of labor and capital links the rate of growth of the capital installed in the tradable sector to that of the capital installed in the nontradable sector.

Using (4), (14), (15), (16)-(25) and (A8) (see the Appendix), one can derive the system of difference equations in X_{Ht}, Z_{ust}, and L_{usTt}—where $X_{Ht} \equiv \frac{K_{euHt}}{K_{usHt}}$ and $Z_{it} \equiv \frac{K_{it}}{K_{iHt}}$ --which governs the equilibrium path of the world economy:

$$X_{Ht+1} = X_{Ht} \frac{(1-\tau_{euK})}{(1-\tau_{usK})}, \tag{26}$$

$$Z_{ust+1} = f\left(Z_{ust}, \frac{L_{usTt}}{(L - L_{usTt})} \right), \tag{27}$$

$$\frac{L_{usTt+1}}{(L - L_{usTt+1})} = g\left(X_{Ht}, \frac{L_{usTt}}{(L - L_{usTt})} \right), \tag{28}$$

where $f(.) = \frac{(Z_{ust} - 1)}{\theta(1-\tau_{usK})} - \frac{1}{\theta(1-\mu)(1-\gamma)} \left\{ \mu(1-\beta) - \frac{L_{usTt}[(1-\mu)\gamma + \beta\mu(1-\tau_{usL})]}{(L - L_{usTt})(1-\tau_{usL})} \right\}$ and

$$g(.) = \frac{L_{usTt}\left\{ (1-\tau_{usK})\left[\frac{(1-\mu)\gamma}{(1-\tau_{usL})} + \beta\mu \right] + X_{Ht}(1-\tau_{euK})\left[\frac{(1-\mu)\gamma}{(1-\tau_{euL})} + \beta\mu \right] \right\}}{(L - L_{usTt})(1-\alpha)\theta\left\{ (1-\tau_{usK})^2\left[\frac{(1-\mu)\gamma}{(1-\tau_{usL})} + \beta\mu \right] + X_{Ht}(1-\tau_{euK})^2\left[\frac{(1-\mu)\gamma}{(1-\tau_{euL})} + \beta\mu \right] \right\}} -$$

$$- \frac{\alpha(1-\mu)(1-\gamma)\left\{ \frac{X_{Ht}(1-\tau_{euK})^2(1-\beta)\mu}{(1-\mu)(1-\gamma)} + X_{Ht}(1-\tau_{euK}) + \frac{(1-\tau_{usK})^2(1-\beta)\mu}{(1-\mu)(1-\gamma)} + (1-\tau_{usK}) \right\}}{(1-\alpha)\left\{ (1-\tau_{usK})^2\left[\frac{(1-\mu)\gamma}{(1-\tau_{usL})} + \beta\mu \right] + X_{Ht}(1-\tau_{euK})^2\left[\frac{(1-\mu)\gamma}{(1-\tau_{euL})} + \beta\mu \right] \right\}}.$$

The equilibrium path governed by (26)-(28) is studied under the assumption that $\tau_{euK} \geq \tau_{usK}$ and $\tau_{euL} > \tau_{usL}$.

Case in which $\tau_{euK} > \tau_{usK}$ and $\tau_{euL} > \tau_{usL}$

In this case, the following proposition holds:

Proposition 1 If $\tau_{euK} > \tau_{usK}$ and $\tau_{euL} > \tau_{usL}$, i) the equilibrium path of the world economy is unique, ii) the amount of tradable goods used in the us economy exceeds the us production of tradable goods and the us economy runs a trade deficit for all $t<\infty$, and iii) in the long-term the us GDP grows at a higher rate than the eu GDP.

Proof: See the Appendix.

The unique equilibrium path of the two-country economy is such that as $t\to\infty$ $X_{Ht}\to X^{\circ}_{H}$, $Z_{ust}\to Z^{\circ}_{us}$ and $L_{usTt}\to L^{\circ}_{usT}$, where "$\circ$" denotes the long-term equilibrium value of a variable when the markets are internationally integrated and $\tau_{euK}>\tau_{usK}$. Along this path, X_{Ht}, Z_{ust} and L_{usTt} converge monotonically to their respective long-term values (see figures 1 and 2), and the buoyant demand for the tradable good coming from the low-tax country is partially met by the production of the high-tax country. This is at the origin of the persistent trade deficit of the low-tax country, which vanishes only as $t\to\infty$, since asymptotically the fraction of the us demand for the tradable good that is met by the eu production becomes negligible because of the permanent growth differential between the two countries. Indeed, the country taxing the capital income less heavily tends to grow faster because the capital installed by its firms grows at a higher rate, and this growth differential is preserved forever.

Case in which $\tau_{euK}=\tau_{usK}$ and $\tau_{euL}>\tau_{usL}$

In this case, the following proposition holds:

Proposition 2 If $\tau_{euK}=\tau_{usK}$ and $\tau_{euL}>\tau_{usL}$, i) the equilibrium path of the world economy is unique, ii) the amount of tradable goods used in the us economy exceeds the us production of tradable goods and the us economy runs a trade deficit for all t, iii) the us GDP and the eu GDP grow at the same rate, and iv) this equilibrium rate of growth is increasing with the fraction of the world stock of capital that is initially owned by the us households.

Proof: See the Appendix.

FIGURE 1
Phase line of eq. (27)

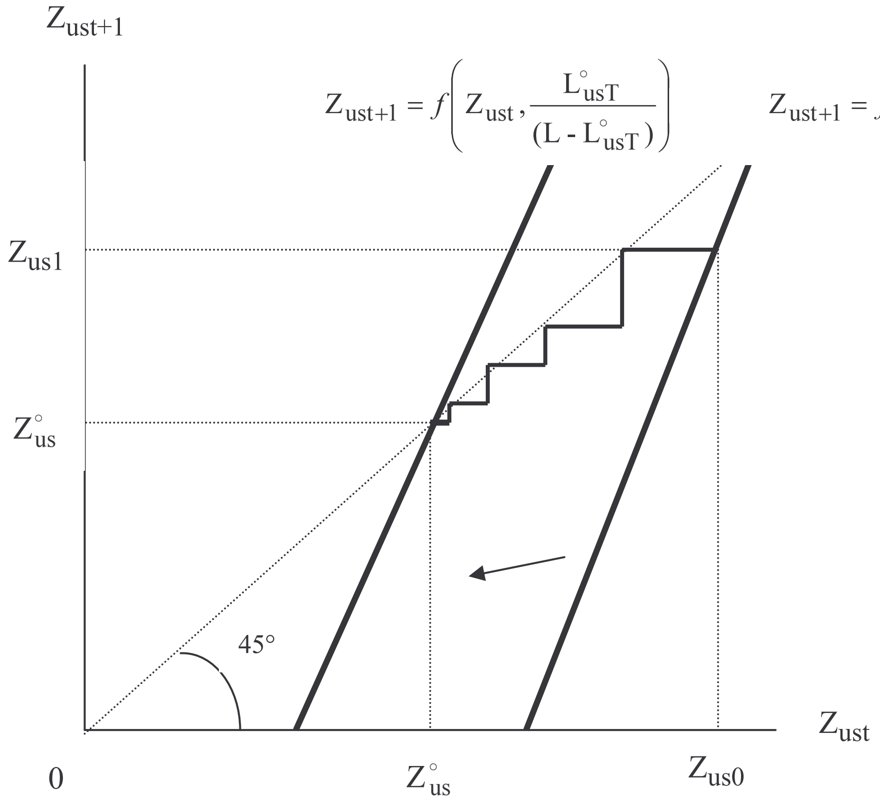
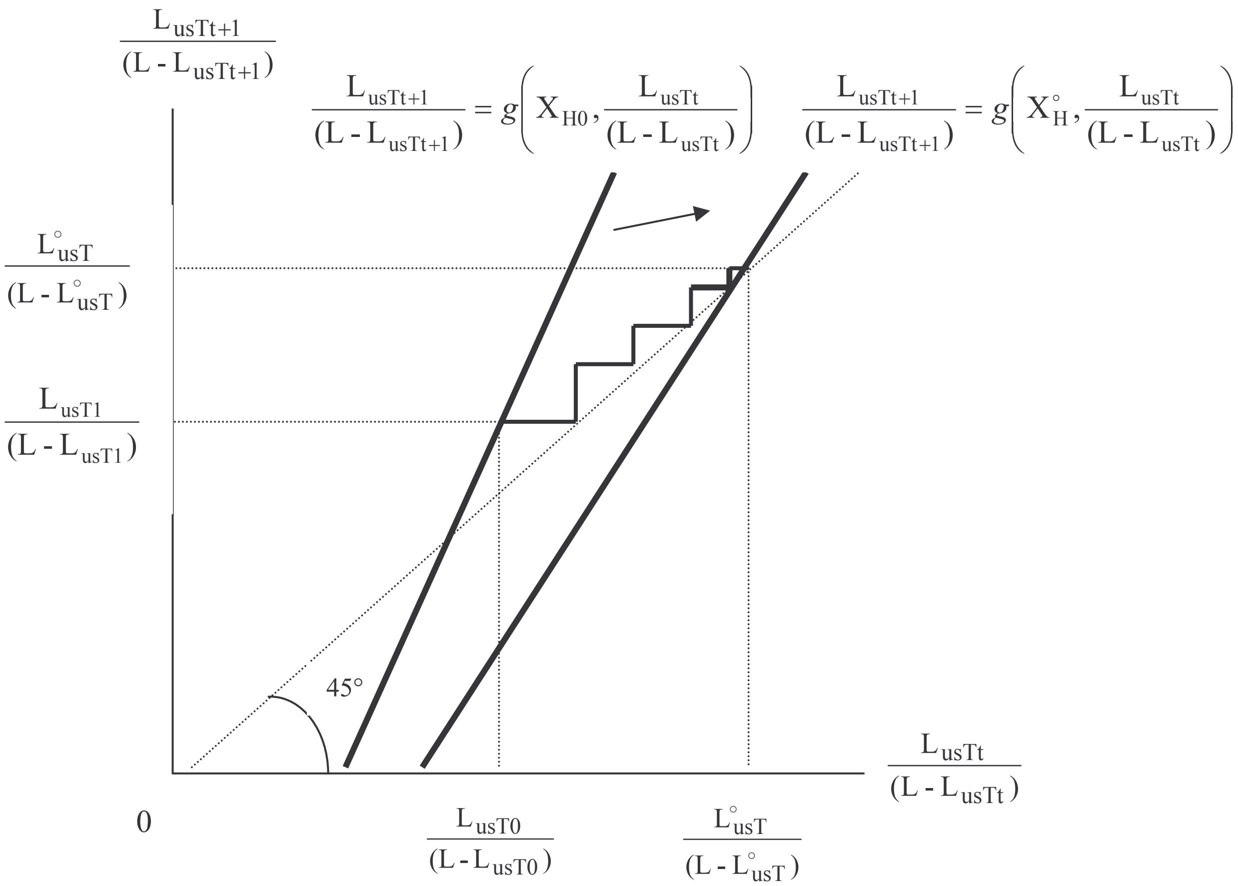


FIGURE 2
Phase line of eq. (28)



The unique equilibrium path of the two-country economy is such that $X_{Ht} = X_{H}^{*}$, $Z_{ust} = Z_{us}^{*}$ and $L_{usTt} = L_{usT}^{*}$ for all t, where "*" denotes the equilibrium value of a variable when the markets are internationally integrated and $\tau_{euK}=\tau_{usK}$. Along this equilibrium path, the fraction of the world stock of capital that is owned by the us households does not change, and the initial distribution of the world stock of capital between the us and the eu households has a permanent influence on the equilibrium values of X_{Ht}, Z_{ust} and L_{usTt}.

In the country where labor is taxed more heavily, namely in the eu, households devote less time to market activities and tend to reduce their demand for the market goods, thus depressing the domestic production of the nontradable good. In contrast, the eu production of the tradable good is not depressed by the weak domestic demand for market goods, since the eu exports a portion of its tradable output to the us, where the demand for market goods tends to be more buoyant. As a result, the us trade account is permanently negative even if the two economies grow at the same rate.

Since the pace of technological progress depends on the rate at which in each country the tradable sector expands, and since the world demand for the tradable good is higher if the weight of the us households in the world demand for the tradable good is greater, a distribution of the world stock of wealth more favorable to the us households raises the equilibrium rate of growth of the world economy.

Consequences of a cut in the eu tax rate on capital income for the us growth performance

Suppose that initially $\tau_{euK}>\tau_{usK}$ and $\tau_{euL}>\tau_{usL}$ and that then the eu authorities decide a tax cut aimed at making the tax rates on capital income equal across countries. This cut worsens the long-term growth performance of the us economy:

Proposition 3 If $\tau_{euK}>\tau_{usK}$ and $\tau_{euL}>\tau_{usL}$, a cut in the eu tax rate on capital income from τ_{euK} to $\tau'_{euK} = \tau_{usK}$ determines a decrease in the long-term rate of growth of the us GDP.

Proof: See the Appendix.

When $\tau_{euK}>\tau_{usK}$ and $\tau_{euL}>\tau_{usL}$, there is a permanent growth differential in favor of the us economy and the us demand for the tradable good is increasingly met by the domestic production. This does not occur when $\tau'_{euK} = \tau_{usK}$ and $\tau_{euL}>\tau_{usL}$: even in the long run--under these circumstances—a significant portion of the us demand for the tradable good is met by the eu production. Therefore, the us tradable sector remains smaller and attracts relatively less labor and capital when the tax rates on capital income are equalized. As a result, the long-term rate of growth of the us economy is lower when $\tau'_{euK} = \tau_{usK}$ and $\tau_{euL}>\tau_{usL}$, since the technological progress feeding the growth process takes place in the tradable sector.

International market integration versus autarky

Proposition 4 If $\tau_{euK}\geq\tau_{usK}$ and $\tau_{euL}>\tau_{usL}$, in the long term the eu economy devotes more time to market activities (even if it devotes less time to the production of the nontradable good) and has a higher rate of GDP growth under international market integration than under autarky.

Proof: See the Appendix

The fact that the production of the tradable good is partially driven in the high-tax country by the demand generated by the faster growing country explains why the eu economy exhibits a higher long-term rate of growth under international market integration than it would have under autarky (when this external stimulus would be absent). It explains also why the eu economy has a higher larger fraction of its total population employed in the tradable sector (and higher K_{euTt}/K_{euNt} and K_{euTt}/K_{euHt} ratios) when the markets are internationally integrated than it would have under autarky.

4 CONCLUSION

The two-country model developed in this paper intends to study economies that differ only with respect to tax rates (labor income taxes and possibly capital income taxes). The analysis is conducted under the simplifying assumptions that total work time (market work plus time devoted to home activities) is the same in the two countries and that the (internationally) tradable goods coincide with the market goods that have no home-produced substitutes. In this setup, it is shown that market work is higher in the country with the lower tax rate on labor income, that the higher market work characterizing the country with the lower tax rate on labor income is entirely due to higher employment in the sector producing services that have close home-produced substitutes, and that the country with the lower tax rate on labor income has a persistent trade deficit.

Future research can extend this framework by distinguishing between those home activities producing consumer services that may also be produced in the market and those home activities whose output has no market-produced substitutes. In this way, one may better understand how different policies and institutions interact with technological progress in shaping the allocation of time in the advanced economies.

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APPENDIX

Agents' optimality conditions

The firms producing the nontradable good in country i satisfy the following optimality conditions:

$$\beta\left(\frac{K_{iNt}}{L_{iNt}}\right)^{1-\beta} = W_{it}, \tag{A1}$$

$$(1-\beta)\left(\frac{K_{iNt}}{L_{iNt}}\right)^{-\beta} = R_{it}. \tag{A2}$$

Similarly, the firms producing the tradable good in country i satisfy the following optimality conditions:

$$\frac{P_{it}\alpha K_{iTt}}{L_{iTt}^{1-\alpha}} = W_{it}, \tag{A3}$$

$$P_{it}(1-\alpha)L_{iTt}^{\alpha} = R_{it}. \tag{A4}$$

One can solve the households' problem by maximizing

$$\sum_{n=t}^{\infty}\theta^{n-t}\Big\{\mu\ln(N_{in})+(1-\mu)\ln(K_{iHn}^{1-\gamma}L_{iHn}^{\gamma})-\lambda_{in}[K_{in+1}P_{in}+N_{in}-(K_{in}-K_{iHn})R_{in}(1-\tau_{iK})-$$

$-(L-L_{iHn})W_{in}(1-\tau_{iL})-G_{in}]\Big\}$ with respect to N_{it}, K_{iHt}, L_{iHt}, K_{it+1} and the Lagrange multiplier λ_{it}, and then by eliminating λ_{it}, thus obtaining:

$$K_{iNt}=\frac{K_{iHt}(1-\beta)\mu(1-\tau_{iK})}{(1-\mu)(1-\gamma)}, \tag{A5}$$

$$L_{iNt}=\frac{L_{iHt}\beta\mu(1-\tau_{iL})}{(1-\mu)\gamma}, \tag{A6}$$

$$\rho_{iHt}=\theta(1-\alpha)(1-\tau_{iK})L_{iTt}^{\alpha}-1,\ \rho_{iHt}\equiv\frac{K_{iHt+1}-K_{iHt}}{K_{iHt}}, \tag{A7}$$

$$\theta(1-\tau_{iK})Z_{it+1}=Z_{it}-\frac{(1-\tau_{iK})}{(1-\mu)(1-\gamma)}\left\{\mu(1-\beta)-\frac{L_{iTt}[(1-\mu)\gamma+\beta\mu(1-\tau_{iL})]}{(1-\tau_{iL})(L-L_{iTt})}\right\}-1,\ Z_{it}\equiv\frac{K_{it}}{K_{iHt}}. \tag{A8}$$

Therefore, along an optimal path a household located in i must satisfy (A5)-(A8) and the transversality condition

$$\lim_{t\to\infty}\theta^{t}Z_{it}\mu\left(\frac{K_{iHt}(1-\beta)\gamma(1-\tau_{iK})}{L_{iHt}\beta(1-\gamma)(1-\tau_{iL})}\right)^{\beta}=0. \tag{A9}$$

Proof of Proposition 1

i) If $\tau_{euK}>\tau_{usK}$, one can verify that the triple $(X_H^{\circ},Z_{us}^{\circ},L_{usT}^{\circ})$ satisfying $X_{Ht+1}=X_{Ht}=X_H^{\circ}$, $Z_{ust+1}=Z_{ust}=Z_{us}^{\circ}$ and $L_{usTt+1}=L_{usTt}=L_{usT}^{\circ}$ in equations (26)-(28) is unique, where

$$X_H^{\circ}=0, \tag{A10}$$

$$Z_{us}^{\circ}=\frac{\dfrac{(1-\tau_{usK})}{(1-\gamma)(1-\mu)}\left\{\mu(1-\beta)-\dfrac{L_{usT}^{\circ}}{(L-L_{usT}^{\circ})}\left[\dfrac{\gamma(1-\mu)}{(1-\tau_{usL})}+\beta\mu\right]\right\}+1}{[1-\theta(1-\tau_{usK})]}, \tag{A11}$$

$$L_{usT}^{\circ}=\frac{L\left[\dfrac{(1-\tau_{usK})(1-\beta)\mu}{(1-\gamma)(1-\mu)}+1\right]\theta\alpha(1-\gamma)(1-\mu)(1-\tau_{usL})}{[1-\theta(1-\alpha)(1-\tau_{usK})][\gamma(1-\mu)+\beta\mu(1-\tau_{usL})]+\left[\dfrac{(1-\tau_{usK})(1-\beta)\mu}{(1-\gamma)(1-\mu)}+1\right]\theta\alpha(1-\gamma)(1-\mu)(1-\tau_{usL})}. \tag{A12}$$

A formal proof of the uniqueness of the equilibrium path in a neighborhood of $(X^{\circ}_{H}, Z^{\circ}_{us}, L^{\circ}_{usT})$ is provided by linearizing (26)-(28) around $(X^{\circ}_{H}, Z^{\circ}_{us}, L^{\circ}_{usT})$, thus obtaining the following characteristic equation: $\left[\frac{(1-\tau_{euK})}{(1-\tau_{usK})}-\chi\right]\left[\frac{1}{\theta(1-\tau_{usK})}-\chi\right]\left[\frac{1}{\theta(1-\alpha)(1-\tau_{usK})}-\chi\right]=0$, where $\chi_1=\frac{(1-\tau_{euK})}{(1-\tau_{usK})}$, $\chi_2=\frac{1}{\theta(1-\tau_{usK})}$ and $\chi_3=\frac{1}{\theta(1-\alpha)(1-\tau_{usK})}$ are the solving characteristic roots. Given that $\chi_1<1$, $\chi_2>1$ and $\chi_3>1$, one has saddle-path stability: the saddle path is the unique equilibrium trajectory of the world economy in a neighborhood of $(X^{\circ}_{H}, Z^{\circ}_{us}, L^{\circ}_{usT})$ since any other path satisfying (26)-(28) violates transversality or boundary conditions. Indeed, the linearized system characterizes a unique path converging to $(X^{\circ}_{H}, Z^{\circ}_{us}, L^{\circ}_{usT})$:

$$X_{Ht}-X^{\circ}_{H}=mq_{11}\chi_1^t, \tag{A13}$$

$$Z_{ust}-Z^{\circ}_{us}=mq_{21}\chi_1^t, \tag{A14}$$

$$L_{usTt}-L^{\circ}_{usT}=mq_{31}\chi_1^t, \tag{A15}$$

where $m=\frac{F}{2D}-\sqrt{\left(\frac{F}{2D}\right)^2+\frac{G}{D}}<0$, $F\equiv(K_{us0}+K_{eu0})\left\{q_{21}(L-L^{\circ}_{usT})-Z^{\circ}_{us}-\frac{(1-\alpha)(1-\tau_{usK})[\gamma(1-\mu)+\beta\mu(1-\tau_{usL})]}{(1-\gamma)(1-\mu)\alpha(1-\tau_{usL})}\right\}+$

$+K_{us0}\left\{\left[\frac{(1-\tau_{usK})(1-\beta)\mu}{(1-\gamma)(1-\mu)}+1\right]-q_{11}(L-L^{\circ}_{usT})\left[\frac{(1-\tau_{euK})(1-\beta)\mu}{(1-\gamma)(1-\mu)}+1\right]-\frac{q_{11}L^{\circ}_{usT}(1-\alpha)(1-\tau_{euK})}{(1-\gamma)(1-\mu)\alpha}\left[\frac{\gamma(1-\mu)}{(1-\tau_{euL})}+\beta\mu\right]\right\}$,

$D\equiv(K_{us0}+K_{eu0})q_{21}-K_{us0}q_{11}\left\{\left[\frac{(1-\tau_{euK})(1-\beta)\mu}{(1-\gamma)(1-\mu)}+1\right]-\frac{(1-\alpha)(1-\tau_{euK})}{(1-\gamma)(1-\mu)\alpha}\left[\frac{\gamma(1-\mu)}{(1-\tau_{euL})}+\beta\mu\right]\right\}$,

$G\equiv(K_{us0}+K_{eu0})Z^{\circ}_{us}(L-L^{\circ}_{usT})-K_{us0}\left\{\left[\frac{(1-\tau_{usK})(1-\beta)\mu}{(1-\gamma)(1-\mu)}+1\right](L-L^{\circ}_{usT})+\frac{L^{\circ}_{usT}(1-\alpha)(1-\tau_{usK})}{(1-\gamma)(1-\mu)\alpha}\left[\frac{\gamma(1-\mu)}{(1-\tau_{usL})}+\beta\mu\right]\right\}$,

$$q_{11}=\frac{-[1-\theta(1-\alpha)(1-\tau_{usK})]}{\theta^2(1-\alpha)(1-\tau_{usK})^2(1-\tau_{euK})\left\{\frac{[1-\theta(1-\alpha)(1-\tau_{euK})]}{[1-\theta(1-\alpha)(1-\tau_{usK})]}\left[\frac{(1-\tau_{usK})(1-\beta)\mu}{(1-\gamma)(1-\mu)}+1\right]-\left[\frac{(1-\tau_{euK})(1-\beta)\mu}{(1-\gamma)(1-\mu)}+1\right]\right\}}<0,$$

$$q_{21}=\frac{\left\{[1-\theta(1-\alpha)(1-\tau_{usK})][\gamma(1-\mu)+\beta\mu(1-\tau_{usL})]+\left[\frac{(1-\tau_{usK})(1-\beta)\mu}{(1-\gamma)(1-\mu)}+1\right]\theta\alpha(1-\gamma)(1-\mu)(1-\tau_{usL})\right\}^2(1-\tau_{usK})}{L(1-\gamma)(1-\mu)(1-\tau_{usL})[\theta(1-\tau_{euK})-1][\gamma(1-\mu)+\beta\mu(1-\tau_{usL})][1-\theta(1-\alpha)(1-\tau_{usK})]^2}<0,$$

$q_{31}=1$, K_{us0} and K_{eu0} given.

ii) Considering (14) and (15), one can easily check that the difference between the tradable goods demanded to be used in the us economy and the us production of tradable goods, ED_{usTt}, is given by $ED_{usTt}=K_{usTt+1}+K_{usNt+1}+K_{usHt+1}-T_{ust}$, which--using (4), (19), (20) and (25)--can be rewritten as

$$ED_{usTt} = \frac{(1-\alpha)(1-\tau_{usK})}{K_{usHt}^{-1} L_{usTt}^{-\alpha}} \left\{ \theta + \frac{(1-\beta)\mu(1-\tau_{usK})\theta}{(1-\mu)(1-\gamma)} - \frac{L_{usTt}[(1-\mu)\gamma + \beta\mu(1-\tau_{usL})][1-\theta(1-\alpha)(1-\tau_{usK})]}{(L - L_{usTt})(1-\tau_{usL})(1-\mu)(1-\gamma)\alpha} \right\}. \tag{A16}$$

By substituting L°_{usT} for L_{usTt} in (A16), one can verify that $ED_{usTt} \to 0$ as $t \to \infty$.

Moreover, one can easily check in (A16) that $ED_{usTt}>0$ whenever $L_{usTt}< L^{\circ}_{usT}$. Hence, a formal proof of the fact that $ED_{usTt}>0$ for all $t<\infty$ in a neighborhood of $(X^{\circ}_{H}, Z^{\circ}_{us}, L^{\circ}_{usT})$ is provided by (A15), which shows that $L_{usTt}< L^{\circ}_{usT}$ for all $t<\infty$.

The us trade account, TA_{ust}, is given by $TA_{ust}=P_{ust}(T_{ust}-K_{ust+1})$, which--using (4), (20), (24) and (25)—can be rewritten as

$$TA_{ust} = (1-\tau_{usK})(1-\beta)K_{usHt} \left(\frac{L_{usNt}}{K_{usNt}} \right)^{\beta} \left\{ \frac{L_{usTt}[(1-\mu)\gamma + \beta\mu(1-\tau_{usL})]}{(L - L_{usTt})(1-\tau_{usL})(1-\mu)(1-\gamma)\alpha} - \theta Z_{ust+1} \right\}. \tag{A17}$$

By substituting L°_{usT} for L_{usTt} and Z°_{us} for Z_{ust+1} in (A17), one can verify that $TA_{ust} \to 0$ as $t \to \infty$. Moreover, one can easily check in (A17) that $TA_{ust}<0$ whenever $L_{usTt}< L^{\circ}_{usT}$ and $Z_{ust+1}> Z^{\circ}_{us}$. Hence, a formal proof of the fact that $TA_{ust}<0$ for all $t<\infty$ in a neighborhood of $(X^{\circ}_{H}, Z^{\circ}_{us}, L^{\circ}_{usT})$ is provided by (A14) and (A15), which show that $L_{usTt}< L^{\circ}_{usT}$ and $Z_{ust+1}> Z^{\circ}_{us}$ for all $t<\infty$.

iii) The GDP of country i, GDP_{it}, is given by $GDP_{it}=N_{it}+P_{it}T_{it}$, whose rate of growth is

$\rho_{iGDPt} = \dfrac{N_{it+1} + P_{it+1}T_{it+1} - (N_{it} + P_{it}T_{it})}{N_{it} + P_{it}T_{it}}$, $\rho_{iGDPt} \equiv \dfrac{GDP_{it+1} - GDP_{it}}{GDP_{it}}$. By using (1), (4), (16), (18), (19), (20), (24) and (25), one can check that $\rho^{\circ}_{usGDP} > \rho^{\circ}_{euGDP}$, where

$$\rho^{\circ}_{iGDP} = \lim_{t\to\infty} \rho_{iGDPt} = \left[\theta(1-\alpha)(1-\tau_{iK})(L^{\circ}_{iT})^{\alpha} \right]^{1-\beta} - 1.^{9} \tag{A18}$$

[9] It is easy to show that if in each country the numéraire were the tradable good, one would have:

Proof of Proposition 2

i) If $\tau_{euK}=\tau_{usK}$, eq. (26) entails $X_{Ht}=X_{H0}$ for all t. Given $X_{Ht}=X_{H0}$ and $\dfrac{\partial g\left(X_{H0},\dfrac{L_{usTt}}{(L-L_{usTt})}\right)}{\partial \dfrac{L_{usTt}}{(L-L_{usTt})}}>1$ for all t, it turns out that the only path which satisfies (28) and does not violate boundary conditions must be such that

$$\frac{L^*_{usT}}{(L-L^*_{usT})}=g\left(X_{H0},\frac{L^*_{usT}}{(L-L^*_{usT})}\right) \text{ for all t.} \tag{A19}$$

Given $L_{usTt}=L^*_{usT}$ and $\dfrac{\partial f\left(Z_{ust},\dfrac{L^*_{usT}}{(L-L^*_{usT})}\right)}{\partial Z_{ust}}>1$ for all t, it turns out that the only path which satisfies (27) and does not violate transversality or boundary conditions must be such that

$$Z^*_{us}=f\left(Z^*_{us},\frac{L^*_{usT}}{(L-L^*_{usT})}\right) \text{ for all t.} \tag{A20}$$

Given (16), (19), (20), $L_{usTt}=L^*_{usT}$ and $Z_{ust}=Z^*_{us}$ for all t, at t=0 one has:

$$K_{us0}+K_{eu0}=K_{usH0}\left\{1+\frac{(1-\beta)\mu(1-\tau_{usK})}{(1-\mu)(1-\gamma)}+\frac{L^*_{usT}(1-\tau_{usK})(1-\alpha)}{(L-L^*_{usT})(1-\mu)(1-\gamma)\alpha}\left[\frac{(1-\mu)\gamma}{(1-\tau_{usL})}+\beta\mu\right]\right\}+$$
$$+K_{usH0}X_{H0}\left\{1+\frac{(1-\beta)\mu(1-\tau_{euK})}{(1-\mu)(1-\gamma)}+\frac{L^*_{usT}(1-\tau_{euK})(1-\alpha)}{(L-L^*_{usT})(1-\mu)(1-\gamma)\alpha}\left[\frac{(1-\mu)\gamma}{(1-\tau_{euL})}+\beta\mu\right]\right\}, \text{ which entails}$$

$$Z^*_{us}=\frac{K_{us0}}{(K_{us0}+K_{eu0})}\left\{1+\frac{(1-\beta)\mu(1-\tau_{usK})}{(1-\mu)(1-\gamma)}+\frac{L^*_{usT}(1-\tau_{usK})(1-\alpha)}{(L-L^*_{usT})(1-\mu)(1-\gamma)\alpha}\left[\frac{(1-\mu)\gamma}{(1-\tau_{usL})}+\beta\mu\right]\right\}+$$
$$+\frac{K_{us0}X_{H0}}{(K_{us0}+K_{eu0})}\left\{1+\frac{(1-\beta)\mu(1-\tau_{euK})}{(1-\mu)(1-\gamma)}+\frac{L^*_{usT}(1-\tau_{euK})(1-\alpha)}{(L-L^*_{usT})(1-\mu)(1-\gamma)\alpha}\left[\frac{(1-\mu)\gamma}{(1-\tau_{euL})}+\beta\mu\right]\right\}, \tag{A21}$$

where K_{us0} and K_{eu0} are given.

$\lim_{t\to\infty}\rho_{usGDPt}=\theta(1-\alpha)(1-\tau_{usK})(L^{\circ}_{usT})^{\alpha}-1>\lim_{t\to\infty}\rho_{euGDPt}=\theta(1-\alpha)(1-\tau_{euK})(L^{\circ}_{euT})^{\alpha}-1$.

Having shown that $X_{Ht} = X_{H0}$, $L_{usTt} = L^*_{usT}$ and $Z_{ust} = Z^*_{us}$ for all t, one can prove the uniqueness of the equilibrium path of the world economy when τ_{euK}=τ_{usK} by checking that the triple $(X_{H0}, Z^*_{us}, L^*_{usT})$ which solves (A19)-(A21) is unique, where

$$X_{H0} = X^*_H = \frac{\left\{1 + \frac{(1-\beta)\mu(1-\tau_{usK})}{(1-\mu)(1-\gamma)} - \frac{L^*_{usT}(1-\tau_{usK})}{(L-L^*_{usT})(1-\mu)(1-\gamma)}\left[\frac{(1-\mu)\gamma}{(1-\tau_{usL})} + \beta\mu\right]\right\}(K_{us0}+K_{eu0})}{[1-\theta(1-\tau_{usK})]\left\{1 + \frac{(1-\beta)\mu(1-\tau_{euK})}{(1-\mu)(1-\gamma)} + \frac{L^*_{usT}(1-\tau_{euK})(1-\alpha)}{(L-L^*_{usT})(1-\mu)(1-\gamma)\alpha}\left[\frac{(1-\mu)\gamma}{(1-\tau_{euL})} + \beta\mu\right]\right\}K_{us0}} -$$

$$- \frac{\left\{1 + \frac{(1-\beta)\mu(1-\tau_{usK})}{(1-\mu)(1-\gamma)} + \frac{L^*_{usT}(1-\tau_{usK})(1-\alpha)}{(L-L^*_{usT})(1-\mu)(1-\gamma)\alpha}\left[\frac{(1-\mu)\gamma}{(1-\tau_{usL})} + \beta\mu\right]\right\}}{\left\{1 + \frac{(1-\beta)\mu(1-\tau_{euK})}{(1-\mu)(1-\gamma)} + \frac{L^*_{usT}(1-\tau_{euK})(1-\alpha)}{(L-L^*_{usT})(1-\mu)(1-\gamma)\alpha}\left[\frac{(1-\mu)\gamma}{(1-\tau_{euL})} + \beta\mu\right]\right\}}, \quad \text{(A22)}$$

$$Z^*_{us} = \frac{\frac{(1-\tau_{usK})}{(1-\gamma)(1-\mu)}\left\{\mu(1-\beta) - \frac{L^*_{usT}}{(L-L^*_{usT})}\left[\frac{\gamma(1-\mu)}{(1-\tau_{usL})} + \beta\mu\right]\right\} + 1}{[1-\theta(1-\tau_{usK})]}, \quad \text{(A23)}$$

$$L^*_{usT} = \frac{L\left[\frac{Q}{2M} - \sqrt{\left(\frac{Q}{2M}\right)^2 - \frac{V}{M}}\right]}{\left[1 + \frac{Q}{2M} - \sqrt{\left(\frac{Q}{2M}\right)^2 - \frac{V}{M}}\right]}, \quad \text{(A24)}$$

$$V \equiv \theta\left[1 + \frac{(1-\beta)\mu(1-\tau_{usK})}{(1-\mu)(1-\gamma)}\right]^2, \quad M \equiv \frac{[1-\theta(1-\tau_{usK})(1-\alpha)]}{\alpha(1-\mu)^2(1-\gamma)}\left[\frac{\gamma(1-\mu)}{(1-\tau_{euL})} + \beta\mu\right]\left[\frac{\gamma(1-\mu)}{(1-\tau_{usL})} + \beta\mu\right],$$

$$Q \equiv \left[1 + \frac{(1-\beta)\mu(1-\tau_{usK})}{(1-\mu)(1-\gamma)}\right]\left\{\frac{\theta(1-\tau_{usK})}{(1-\mu)}\left[\frac{\gamma(1-\mu)}{(1-\tau_{usL})} + \beta\mu\right] - \left[\frac{1}{(1-\tau_{euL})} - \frac{1}{(1-\tau_{usL})}\right]\frac{\gamma K_{us0}[1-\theta(1-\tau_{usK})]}{\alpha(K_{us0}+K_{eu0})}\right\} +$$

$$+ \frac{[1-\theta(1-\tau_{usK})(1-\alpha)]}{\alpha(1-\mu)}\left[1 + \frac{(1-\beta)\mu(1-\tau_{usK})}{(1-\mu)(1-\gamma)}\right]\left[\frac{\gamma(1-\mu)}{(1-\tau_{euL})} + \beta\mu\right],$$ K_{us0} and K_{eu0} given.

ii) By substituting L^*_{usT} for L_{usTt} in (A16), one can verify that ED_{usTt}>0 for all t.

Similarly, by substituting L^*_{usT} for L_{usTt} and Z^*_{us} for Z_{ust+1} in (A17), one can verify that TA_{ust}<0 for all t.

iii) By using (1), (4), (16), (18), (19), (20), (24) and (25), one can check that $\rho^*_{usGDPt} = \rho^*_{euGDPt}$ for all t, where

$$\rho^*_{iGDPt} = \rho^*_{iGDP} = \left[\theta(1-\alpha)(1-\tau_{iK})(L^*_{iT})^{\alpha}\right]^{1-\beta} - 1.^{10} \quad \text{(A25)}$$

iv) By using (A24) and (A25), one can check that $\dfrac{\partial \rho^*_{iGDPt}}{\partial \dfrac{K_{us0}}{(K_{us0}+K_{eu0})}} > 0$.

Proof of Proposition 3

If $\tau_{euK} > \tau_{usK}$ and $\tau_{euL} > \tau_{usL}$, one has $\lim_{t\to\infty} \rho_{usGDPt} = \rho^{\circ}_{usGDP}$, where ρ°_{usGDP} is given by (A18). If the eu tax rate on capital income is cut from τ_{euK} to $\tau'_{euK} = \tau_{usK}$, one has $\lim_{t\to\infty} \rho_{usGDPt} = \rho^*_{usGDP}$, where ρ^*_{usGDP} is given by (A25). By using (A12) and (A24), one can check that $L^{\circ}_{usT} > L^*_{usT}$, thus proving that $\rho^{\circ}_{usGDP} > \rho^*_{usGDP}$.

Proof of Proposition 4

Under autarky, the equilibrium conditions (14) and (15) can be rewritten, respectively, as

$$T_{it}=K_{it+1} \quad \text{(A26)}$$

and

$$K_{it}-K_{iHt}= K_{iTt}+K_{iNt}. \quad \text{(A27)}$$

Using (4), (A1)-(A8) and (A26)-(A27), one can derive the difference equations in Z_{it} and L_{iTt} governing the equilibrium path of the i economy under autarky, thus obtaining $Z_{it+1} = f\left(Z_{it}, \dfrac{L_{iTt}}{(L - L_{iTt})}\right)$ (see (27)) and

$$\frac{L_{iTt+1}}{(L - L_{iTt+1})} = h\left(\frac{L_{iTt}}{(L - L_{iTt})}\right), \quad \text{(A28)}$$

[10] It is easy to show that if in each country the numéraire were the tradable good, one would have: $\rho_{usGDPt} = \theta(1-\alpha)(1-\tau_{usK})(L^*_{usT})^{\alpha} - 1 = \rho_{euGDPt} = \theta(1-\alpha)(1-\tau_{euK})(L^*_{euT})^{\alpha} - 1$ for all t.

where $$h(.)=\frac{L_{iTt}}{(L-L_{iTt})(1-\alpha)\theta(1-\tau_{iK})}-\frac{\alpha(1-\mu)(1-\gamma)\left\{\frac{(1-\tau_{iK})(1-\beta)\mu}{(1-\mu)(1-\gamma)}+1\right\}}{(1-\alpha)(1-\tau_{iK})\left[\frac{(1-\mu)\gamma}{(1-\tau_{iL})}+\beta\mu\right]}.$$

Given $\frac{dh\left(\frac{L_{iTt}}{(L-L_{iTt})}\right)}{d\frac{L_{iTt}}{(L-L_{iTt})}}>1$ for all t, it turns out that the only path which satisfies (A28) and does not violate boundary conditions must be such that

$$\frac{L^{\bullet}_{iT}}{(L-L^{\bullet}_{iT})}=h\left(\frac{L^{\bullet}_{iT}}{(L-L^{\bullet}_{iT})}\right) \text{ for all t,} \tag{A29}$$

where "$\bullet$" denotes the equilibrium value of a variable under autarky and

$$L^{\bullet}_{iT}=\frac{L\left[\frac{(1-\tau_{iK})(1-\beta)\mu}{(1-\gamma)(1-\mu)}+1\right]\theta\alpha(1-\gamma)(1-\mu)(1-\tau_{iL})}{[1-\theta(1-\alpha)(1-\tau_{iK})][\gamma][-\mu)+\beta\mu(1-\tau_{iL})]+\left[\frac{(1-\tau_{iK})(1-\beta)\mu}{(1-\gamma)(1-\mu)}+1\right]\theta\alpha(1-\gamma)(1-\mu)(1-\tau_{iL})}. \tag{A30}$$

If $\tau_{euK}>\tau_{usK}$ and $\tau_{euL}>\tau_{usL}$, one can check that $L^{\bullet}_{euT}<L^{\circ}_{euT}$, where $L^{\bullet}_{euT}$ and $L^{\circ}_{euT}=L^{\circ}_{usT}$ are given, respectively, by (A30) and (A12). Moreover, since also under autarky L_{euHt} and L_{euNt} are given, respectively, by (17) and (18), one can verify that $L^{\bullet}_{euT}<L^{\circ}_{euT}$ entails $L^{\bullet}_{euN}>L^{\circ}_{euN}$ and $L^{\bullet}_{euH}>L^{\circ}_{euH}$, which—in its turn—entails $L-L^{\bullet}_{euH}<L-L^{\circ}_{euH}$. Finally, since also under autarky one can use (1), (4), (16), (18), (19), (20), (24) and (25) to derive the equilibrium rate of GDP growth, one can check that $\rho^{\circ}_{euGDP}>\rho^{\bullet}_{euGDP}$, where ρ°_{euGDP} is given by (A18) and

$$\rho^{\bullet}_{euGDP}=\lim_{t\to\infty}\rho_{euGDPt}=\left[\theta(1-\alpha)(1-\tau_{euK})(L^{\bullet}_{euT})^{\alpha}\right]^{1-\beta}-1. \tag{A31}$$

If $\tau_{euK}=\tau_{usK}$ and $\tau_{euL}>\tau_{usL}$, one can check that $L^{\bullet}_{euT}<L^{*}_{euT}$, where $L^{\bullet}_{euT}$ and $L^{*}_{euT}=L^{*}_{usT}$ are given, respectively, by (A30) and (A24). Moreover, since also under autarky L_{euHt} and L_{euNt} are given, respectively, by (17) and (18), one can verify that $L^{\bullet}_{euT}<L^{*}_{euT}$ entails $L^{\bullet}_{euN}>L^{*}_{euN}$ and $L^{\bullet}_{euH}>L^{*}_{euH}$, which—in its turn—entails $L-L^{\bullet}_{euH}<L-L^{*}_{euH}$. Finally, one can check that $\rho^{*}_{euGDP}>\rho^{\bullet}_{euGDP}$, where ρ^{*}_{euGDP} and $\rho^{\bullet}_{euGDP}$ are given, respectively, by (A25) and (A31).

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