International factor mobility and indeterminacy: the role of labour market rigidities*

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Abstract

We consider a simple two-country overlapping generation model with (possibly, negligible) capital externalities and one output. Countries only differ in labour market structure. In one country the labour market is perfeclty competitive, wages are flexible and there is full employment, while in the other country real wages are rigid. Our parameterisation is such that in autarkic equilibrium the rigid-wage economy exhibits indeterminacy, (i.e. a continuum of equilibrium adjustment paths driven by self-fulfilling expectations), while the other country has a stable determinate steady state. We show that, if externalities are sufficiently small, opening up the economy and allowing for free capital movements may bring indeterminacy to world markets, implying that the flexible-wage country may also experience equilibrium fluctuations. However, determinacy is obtained if, in the rigid-wage country, workers appropriate part of the investment rents. Further, when labour movements are also allowed, similar results are obtained without requiring such small levels of capital externalities.

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1 Introduction

Over the last decade, much research has been devoted to the labour market effects of globalisation and, particularly, to the correlation between unemployment and globalisation. Although the evidence on the incidence of increased trade integration on labour markets in developed countries is by no means conclusive, most researchers share the view that labour market rigidities, coupled with increased trade integration, contributes to the rise in unemployment.[1] Less research, on the other hand, has been devoted to studying the macroeconomic effects (e.g. on employment, wages and output volatility) of increased international economic integration.

If we consider how economic agents perceive the current process of integration of the world economy, where capital is internationally very mobile while labour is only to a limited extent, we are faced with rather conflicting views. On the one hand, capital owners, worldwide, strongly support liberalisation of trade and capital movements. On the other hand, labour owners are increasingly concerned about the impact of globalisation on wages, job security, labour and social standards.[2] The main concern is that increased financial openness can produce unwanted disturbances to economies in so far as domestic capital becomes more responsive to changes in international prices and, correspondingly, magnifies the amplitude of fluctuations in real wages or employment levels. A direct implication of the increased volatility brought by international capital market liberalisation is that the macroeconomic risk is mainly borne by internationally immobile factors (namely,

[1] For an extensive coverage of the literature on these issues see the volumes edited by Greenway and Nelson (2001).

[2] Workers' concern about the impact of globalisation is a worldwide phenomenon (see, e.g. ILO (1999) and Edwards and Lusting (1997)) but is particularly evident in developed countries. Indeed, when firms threaten to relocate worldwide, workers feel greater wage pressure and also experience greater wage and/or employment volatility. As stressed by Rodrik (1997, p.24), "International capital mobility alters the nature of the relationship between workers and contributes to the weakening of unions. To the extent that wages are determined in bargaining between workers and employers, then, an increase in the substitutability of workers results in a lower share of the enterprise surplus ending up with workers". It is also well documented - at least for the US - that increased volatility in labour market conditions also accounts for part of the rise in wage inequality (see e.g. Gottschalk and Moffitt (1994) and Slaughter (1998)). All these things together, contribute to the perception of many workers that globalisation is a race to the bottom (see e.g. the evidence given by Scheve and Slaughter (2001)).

labour).[3]

It is, indeed, a peculiarity of the recent wave of globalisation that increased integration in goods and capital markets is accompanied by increased restrictions in labour movements. Surprisingly, so far very little research has been devoted to analysing the macroeconomic implications of such an asymmetry in the integration process of the world economy. One problem is that the importance of international flows of factors is largely overlooked in standard general equilibrium (neoclassical) trade theory according to which factor mobility and trade in goods can be lumped together via the factor price equalisation theorem. If countries only differ in their factor endowments and/or productivity, free trade (or, alternatively, free factor mobility) is enough to level out divergences across countries. In the 'real' world, however, countries' differences go far beyond differences in factor endowments and/or productivity, and the interactions between international trade in goods and factor movements should not be overlooked.

One, much debated, source of difference across countries lies in labour market institutions. Take, for instance, the widely studied case of Europe versus the U.S. It is often claimed that Europe (particularly, EMU members) should move towards a North American labour market structure to achieve higher employment and to reduce the destabilising effects of globalisation in product and capital markets. The EU and EMU experiences are, undoubtedly, pointing towards a fundamental tension between labour market regulation and economic integration.[4] On the one hand, mounting competition in product markets and rapid capital movements make it harder to sustain existing levels of regulation. On the other hand, the lack of labour mobility and fiscal re-distributive mechanisms in the EU budget, together with the higher exposure to market risks, generate the need to maintain, if not to increase, the level of regulation in labour markets.

Our work is aimed at addressing some of these issues. In particular, our purpose is to analyse how labour market institutions affect countries'

[3]The view that instability in the world market may be linked to globalisation and free capital movements is shared by many researchers, see, e.g., Azariadis and Pissarides (2000), Bhagwati (1998), Krugman (1998), Rodrik (1997), Stiglitz (1999). In particular, Azariadis and Pissarides (2000) develop a dynamic model for a small open economy and show that international capital mobility can substantially amplify fluctuations in unemployment and output. In their model, international capital flows also tend to shift income risk from capital to labour. Similar results are shown by Rodrik (1997) within a static framework.

[4]Bertola and Boeri (2002), particularly, emphasise this trade off.

macroeconomic stability under different regimes. Namely, under free trade and free capital movements (but no labour movements), and under complete liberalisation of goods and factor movements. We develop a dynamic (OLG) model in which there is perfect competition in output and capital markets, there is no trade based on comparative advantages a la Heckscher-Olin and the world is made up of two countries identical in everything except for their labour market structure. In one country the labour market is perfectly competitive, wages are flexible and there is full employment. In the other country, real wages are rigid and there is unemployment. While in the paper we focus on labour unions, our analysis applies also to other settings such as efficiency wages.[5]

We interpret macroeconomic instability (stability) as equilibrium indeterminacy (determinacy). Indeterminacy means that there exist a continuum of equilibrium trajectories, converging to a steady state, along which endogenous variables (such as employment and output) may become volatile due to changes in expectations that end up being self-fulfilling. Our set up is such that, in the rigid-wage country only, the equilibrium level of employment in each period is influenced by expectations of future interest rates through the workers' reservation wage. Considering, first, the closed economy equilibrium, we show that, under plausible restrictions on technology parameters, the flexible wage country always converges to a stable (determinate) equilibrium, whereas the other country displays indeterminacy and, thereby, exhibits equilibrium endogenous fluctuations in output and employment.

Opening up the economy to free trade and free capital movements may bring indeterminacy to world markets and the flexible-wage country may also experience output fluctuations. Intuitively, in a financially integrated world, changes in expectations of future interest rates in one country affect the other through the no arbitrage condition in the capital markets. Moreover, if there is equilibrium indeterminacy in world markets, then, capital flows between countries can be reversed, i.e., depending on expectations of future interest rates each country can be either a net importer or a net exporter of capital. A by-product of our analysis is that such a macroeconomic instability is less likely to occur when workers in the rigid-wage country appropriate a fraction of investment rents (i.e. they are unionised).

These results are strengthened if we also allow for free labour mobility.

[5] We refer the reader to the Appendix for a formal proof of the results that apply to the case of efficiency wages.

In this case, we find that perfectly competitive labour markets in both countries cause indeterminacy, whereas imperfectly competitive labour markets (unions or efficiency wages) in one country bring stability and full employment in the world market. When workers are free to move, what happens is that a shock to expectations, say, a decrease in tomorrow's interest rate, has the immediate effect of inducing higher wages and lower the level of employment in the rigid-wage country and, via the no arbitrage conditions on interest rates and wages, capital in the rigid-wage country flows out and labour flows in. This, in turn, induces higher unemployment of natives of the rigid-wage country. Unemployed in the rigid-wage country will be willing to move to the flexible-wage country if they anticipate (via the no arbitrage condition in the labour market) a salary above their reservation wage, i.e., if employed workers in their own country earn a salary above the competitive wage. In this case, all workers are employed and the world economy converges to a stable determinate steady state. If, on the other hand, perfect competition prevails in both countries, then, unemployed workers have no incentives to move and indetrminacy is exported to the rest of the world.

Our results on the effects of free factor movements can be (loosely) related to Davis (1998), and are in sharp contrast with his findings. In Davis paper the source of rigidity is a minimum wage and, by use of comparative static analysis, it is shown that a move from autarky to free trade doubles unemployment in the rigid-wage country (Europe) while the flexible-wage country (America) suffers no losses in employment and enjoy gains in wage income. More recently, Kreickemeier (2003) has shown that adopting efficiency wages, rather than minimum wages, weakens considerably Davis results, in that, under efficiency wages, employment in both countries adjust to changes in relative prices. Davis(1998) and Kreickemeier (2003) approach, however, differs from our. They use a static Heckscher-Olin framework and focus on autarkic versus free trade equilibria. We, on the contrary, do not assume any trade based on comparative advantages and focus on the role of factor movements on the equilibrium dynamic properties of the system. In this respect, our approach is more related to the work of Lahiri (2001), Sakuragawa and Hamada (2001), Weder (2001) and Meng and Velasco (2003), among others. The papers by Weder and by Meng and Velasco are both extensions of Benhabib and Farmer (1996), and study how moving from a closed to a small open economy with free capital movements renders the condition for indeterminacy more easy to obtain. Lahiri (2001) also focuses on the effects of capital mobility on equilibrium indeterminacy. Our model differs form these works, in that

we study a two-country model with no growth and different labour markets, and consider the effect of both capital and labour mobility on the stability properties of the system. Sakuragawa and Hamada (2001), like us, consider a two-country dynamic OLG model and study the stability properties of the system under autarky and free capital movements. Except for that, however, we do not share any other feature. In Sakuragawa and Hamada (2001), countries differ because of asymmetric information in financial markets and initial level of wealth. Their aim is to analyse the effects of capital market liberalisation on the equilibrium dynamics of developing countries. They show that, depending on the country's stage of development, capital market integration may lead to perverse movements in capital flows, which, eventually, may drive the developing country in a poverty trap state. Lastly, we should mention the works of Bertocchi (2003) and Azariadis and Pissarides (2000). The latter, although by use of a very different approach from our, also emphasise that capital liberalisation may amplify fluctuations in wage income and employment at equilibrium. Bertocchi (2003), also incorporates differential labour market structures within a dynamic, general equilibrium, open economy model. Her analysis, however, focuses on the impact of capital market liberalisation and unionisation on cross-country income converge and distribution.[6]

The paper is organised as follows. Section 2 presents the structure of the model and studies the closed economy. Section 3 focuses on the equilibrium dynamic properties of the world economy under free capital movements, while Section 4 analyses the equlibrium dynamics under both capital and labour mobility. Section 5 concludes.

2 Autarkic Equilibrium

In this section, we present the model and obtain the perfect foresight equilibrium (in the deterministic sense) for the closed economy. The world is made up of two countries that differ only in their labour market structure.

[6] Bertocchi (2003) and Azariadis and Pissarides (2000) both consider dynamic OLG models of a small open economy where only capital moves. In Bertocchi (2003) there is underemployment due to the presence of unions, and the economy converges to a determinate steady state with no equilibrium fluctuations in output and employment. In Azariadis and Pissarides (2000) unemployment exists at equilibrium due to search costs, and equilibrium fluctuations around the steady state are generated through *exogenous* productivity shocks.

In country B the labour market is perfectly competitive, wages are flexible and there is full employment, while in country A wages are rigid due to (constant marginal) disutility of labour and unions. The assumption of a constant marginal disutility of labour suffices to generate unemployment at equilibrium, while the presence of unions implies the possibility of equilibrium real wages above the reservation wage and, thereby, the existence of involuntary unemployment at the individual level. Our approach is to construct a model in which, at the autarkic equilibrium, the rigid-wage country may exhibit equilibrium fluctuations in employment linked to indeterminacy of the steady state. In our model, indeterminacy in country A may arise under autarky because employment at equilibrium is such that the (real) reservation wage is identical to the marginal productivity of labour and, thereby, the equilibrium level of employment in each period is influenced by expectations of future interest rates through the workers' reservation wage.[7] On the other hand, country B's equilibrium in the labour market is reached when real wages are identical to the marginal product of labour at the full employment level, and capital accumulation (here, driven by the wage bill) monotonically converges to the steady state. A condition that is verified as long as the (aggregate) marginal productivity of capital obeys the law of decreasing returns. In the following sub-section we focus on real wage rigidities generated by the existence of labour unions. We refer the reader to the Appendix for the case of rigidities generated by efficiency wages.

2.1 Country A (rigid-wages)

Agents live for two periods. In each period $t = 1, ..., \infty$, a continuum of identical agents with constant mass N_A is born. There is a single output, used as consumption or capital good, which is taken as the numeraire. There are m identical firms and the output market is perfectly competitive.

Agents can only work when young and they only consume when old.

[7] The result that, in a closed economy with linear preferences, indeterminacy may arise for a wide range of parameter values on the fundamentals it is well established in the literature, see, e.g., Benhabib and Perli (1994) and Benhabib and Nishimura (1998). More recently, a number of authors have shown that, in a small open economy, the curvature of the utility function makes no difference for indeterminacy to occur. In fact, indeterminacy can arise because capital mobility allows consumption smoothing through international lending and borrowing at a constant world interest rate, see Lahiri (2001), Meng and Velasco (2003) and Weder (2001).

We assume that preferences of an individual born at t are described by the simple linear utility function, $c_{A,t+1} - ad_t$, where $a > 0$ represents the constant marginal disutility of working, and where $d_t = 1$ if employed and $d_t = 0$ if unemployed. The market for capital services is perfectly competitive, $r_{A,t} > 0$ being the rental rate at period t. Capital is totally depreciated in one period, so that $r_{A,t}$ is also the interest factor. A young employed worker save the wage, $w_{A,t} > 0$, through investment in productive capital goods, which are rented to firms in the next period. This means that $k^h_{A,t+1} = w_{A,t}$, where $k^h_{A,t+1}$ is the amount of capital goods bought in period t by each employed worker that is available for production at the outset of period $t+1$. Rentals from capital are then used for consumption, i.e., $c_{A,t+1} = w_{A,t} r_{A,t+1}$, implying that the indirect utility function of a employed worker is $w_{A,t} r_{A,t+1} - a$. Since the utility of those unemployed is zero, a young individual in period t will prefer to be employed by a firm if wages are above the reservation wage $\bar{w}_{A,t}$ given by the following expression

$$\bar{w}_{A,t} = a/\ r_{t+1}, \tag{1}$$

where $r_{A,t+1}$ is the (correctly) expected value, evaluated at period t, of the interest rate in the next period.

All young agents are unionised and there is one union per firm. Young agents are exogenously and uniformly matched with unions. Therefore, each union represents $n_A = N_A/m$ agents.[8] Employment at a firm level, $l_{A,t}$, and wages, $w_{A,t}$, are decided through efficient bargaining between each union and the corresponding firm.[9] We assume that unions are utilitarian, implying that they seek to maximise the sum of their members' utility, i.e., $w_{A,t} r_{A,t+1} l_{A,t} - a l_{A,t} = l_{A,t} r_{A,t+1} (w_{A,t} - \bar{w}_{A,t})$.

Firms seek to maximise profits. We assume the existence of a multiplicative, and country-specific, capital externality in production whose degree is $v > 0$, and a private production function of a Cobb-Douglas type.[10] The production function of a typical firm is then given by

[8] Workers cannot move between firms.

[9] We choose to focus on an efficient bargain, rather then a right-to-manage, bargaining structure because is analytically more tractable.

[10] We use externalities to combine a social technology that display increasing returns with a competitive behaviour in the output market. Our assumption on externalities is compatible with a standard learning-by-doing argument, whereby the average physical capital stock in the economy, $\overline{k}$, generates a positive externality in the production process of each firm. Although the main results in the paper apply for negligible degrees of

$$\mathcal{A}\overline{k}_{A,t}^{v}k_{A,t}^{\theta}l_{A,t}^{1-\theta} \ \ , 0<\theta<1,$$

where $\mathcal{A}$ is a scale parameter, $\bar{k}_{A,t}$ is the country average level of capital available for production at the outset of period t, which is taken as given by each firm, and $k_{A,t}$ is the level of capital rented by the representative firm.

We use the generalised Nash bargaining solution to obtain the outcome of the bargaining process. We assume that workers cannot sign binding wage contracts; therefore, when the bargain over wages and employment takes place, firms have already committed to rent a given level of capital. Formally, we have to maximize over $l_{A,t}$ and $w_{A,t}$, and subject to $l_{A,t} \leq n_A$, the following objective function,

$$\left(\mathcal{A}\bar{k}_{A,t}^{v}k_{A,t}^{\theta}l_{A,t}^{1-\theta} - w_{A,t}l_{A,t}\right)^{\alpha}\left(r_{A,t+1}l_{A,t}\left(w_{A,t}-\bar{w}_{A,t}\right)\right)^{(1-\alpha)}, \ 0<\alpha<1.$$

Note that the rental cost of capital is netted out in the firms' objective function since it is the fall back element of firms, i.e., something they have to pay whether an agreement is reached or not. Note also that $(1-\alpha)$ is the unions' bargaining power. The first order conditions for $w_{A,t}$ and $l_{A,t}$ to maximize the above objective function are,

$$\bar{w}_{A,t} = (1-\theta)\,\mathcal{A}\bar{k}_{A,t}^{v}k_{A,t}^{\theta}l_{A,t}^{-\theta} \tag{2}$$

$$w_{A,t} = (1-\theta\alpha)\,\mathcal{A}\bar{k}_{A,t}^{v}k_{A,t}^{\theta}l_{A,t}^{-\theta}. \tag{3}$$

We assume that the level of employment, $l_{A,t}$, solving the equations above is such that $l_{A,t} < n_A$. Equation (2) shows that employment at the firm level is set such that the marginal productivity of labour is identical to the reservation wage, for all $\alpha \in (0,1]$. This means that at the temporary equilibrium (i.e., the current equilibrium, given the amount of capital accumulated in the past and given expectations of future interest rate) unions do not influence the level of employment. Equation (3), together with (2),

externalities, in our set up the assumption of $\nu > 0$ is needed to ensure that the steady state is well defined.

shows that wages are set as a fixed markup over the reservation wage, i.e., $w_{A,t}/\bar{w}_{A,t} = (1-\theta\alpha)/(1-\theta)$. The markup factor is higher than 1 if there is some union bargaining power, i.e., $\alpha < 1$. A similar markup factor appears under efficiency wages and imperfect monitoring, as shown in the Appendix. However, under efficiency wages employment at the firm level is set such that the marginal productivity of labour is identical to the wage. Figure 1 below represents the temporary equilibrium for the labor market, in the space $(l_{A,t}, w_{A,t})$. The horizontal line at the value $a/r_{A,t+1}$ can be interpreted as an infinitely elastic labor supply curve (becoming vertical at the full employment level), $a/r_{A,t+1}$ being the reservation wage. The negatively sloped curve represents the marginal productivity of labour (MPL), for a given value of $k_{A,t}$, and can be interpreted as a labour demand curve. The contract curve is vertical, i.e., at the temporary equilibrium union power has no effect on the level of employment. Note, however, that union power influences the level of employment along the intertemporal equilibrium. Indeed, as shown above, unions are able to set wages above the reservation wage, the mark-up depending on the union bargaining strenghth. Since capital accumulation is driven by the wage bill, unions power will indirectly influence, through its general equilibrium effects on the dynamics of capital accumulation, the MPL curve and, thereby, the level of employment.

Fig. 1 here

Anticipating the bargaining outcome, firms choose to rent the level of capital that maximises profits, $\alpha\theta\mathcal{A}\bar{k}^{v}_{A,t}k^{\theta}_{A,t}l^{1-\theta}_{A,t} - r_{A,t}k_{A,t}$, where $l_{A,t}$ satisfies (2). The first order condition is then given as follows,

$$\alpha\theta\mathcal{A}\bar{k}^{v}_{A,t}k^{\theta-1}_{A,t}l^{1-\theta}_{A,t} = r_{A,t}. \tag{4}$$

In the limit case of $\alpha = 1$ we have the perfectly competitive equilibrium, where the wage and the rental cost of capital are determined by the marginal productivity of labour and capital, respectively. At a symmetric equilibrium we have that $\bar{k} = k$ and that the aggregate demand of capital services must be identical to its aggregate supply, i.e., $mk_{A,t+1} = ml_{A,t}k^{h}_{A,t+1} = ml_{A,t}w_{A,t}$. Using the latter and the expressions (2), (3) and (4), we obtain the equilibrium dynamic system in terms of the two state variables (k_A, l_A)

$$k_{A,t+1} = (1-\theta\alpha)\,\mathcal{A}k_{A,t}^{v+\theta}l_{A,t}^{1-\theta} \tag{5}$$

$$l_{A,t+1} = bk_{A,t}^{-(v+\theta)^2/(1-\theta)}l_{A,t}^{-\left(v+\theta-1-\frac{\theta}{1-\theta}\right)}, \tag{6}$$

where $b \equiv \left[\frac{(a/\alpha\theta)}{(1-\theta)(1-\theta\alpha)^{(v+\theta-1)}\mathcal{A}^{(1+v+\theta)}}\right]^{1/(1-\theta)}$.

Definition 1 *An intertemporal equilibrium under autarky with unions is a sequence* $(k_{A,t},\, l_{A,t}) \in \Re^2_{++}$, $t = 1, ...\infty$, *such that (5) and (6) are satisfied.*

Note that k_A is a predetermined variable, its value at any period t being determined by past savings. However, l_A is a non-predetermined variable and its value at any period t is influenced by expectations of future interest rates through the reservation wage. By direct inspection of (1)-(2) and Figure 1 it can be seen that, if in period t the expected interest rate $r_{A,t+1}$ decreases, then, the reservation wage increases. This, given a predetermined value of capital, induces, in turn, a decrease in $l_{A,t}$ (an increase in unemployment).

The steady state (k_A, l_A), where $k_A = k_{A,t} = k_{A,t+1}$ and $l_A = l_{A,t} = l_{A,t+1}$, verifying the above dynamic system, is defined by,[11]

$$\begin{aligned} k_A &= \left[(1-\theta\alpha)\,\mathcal{A}l_A^{1-\theta}\right]^{\frac{1}{1-(\theta+\nu)}} \\ l_A &= b^{\frac{(1-\theta)(1-\theta-\nu)}{\nu}}\left[(1-\alpha\theta)\,\mathcal{A}\right]^{-\frac{(v+\theta)^2}{\nu}}. \end{aligned}$$

By taking the logarithms of the state variables the system (5) and (6) becomes linear, with a Jacobian matrix given as follows,

$$\begin{bmatrix} v+\theta & 1-\theta \\ -\frac{(v+\theta)^2}{1-\theta} & (1-v-\theta)+\frac{\theta}{1-\theta} \end{bmatrix}. \tag{7}$$

[11] We assume that N_A is big enough so that we can ensure that $l_A < n_A \equiv N_A/m$ at the steady state. Therefore, $l_{A,t} \leq n_A$ around the steady state.

The stability properties of the steady state depend on the eigenvalues of the Jacobian matrix whose values are determined by the trace T and the determinant D of the matrix in (7),

$$\begin{aligned} T &= \frac{1}{1-\theta} \\ D &= \frac{\nu+\theta}{1-\theta}. \end{aligned}$$

For indeterminacy to arise, both eigenvalues (in absolute value) must be lower than 1, a case that will be obtained when $D < 1$, $D > T - 1$ and $D > -T - 1$, simultaneously**.** As is well known in this case there are sunspots, i.e., stationary stochastic equilibria driven by volatile self-fulfilling expectations.

It is, then, easy to check that indeterminacy of the steady state in autarky is obtained when $0 < \theta < \frac{1}{2}$ and $0 < v < 1 - 2\theta$, for any value of $\alpha \in (0, 1]$. In the Appendix it is shown that the same conditions apply when there are efficiency wages. The following proposition summarises the results.

Proposition 1 *Assume* $0 < \theta < \frac{1}{2}$ *and* $0 < v < 1 - 2\theta$*. Then, under autarky the rigid-wage economy exhibits equilibrium indeterminacy.*

To ensure this, and further results in next sections, we assume that v and θ satisfy the following restrictions,

$$0 < \theta < \frac{1}{2} \quad \text{and} \quad 0 < v < \frac{1-2\theta}{2}. \tag{8}$$

These restrictions are plausible, since empirical evidence points to low values of the degree of externalities,[12] ν, and values of the capital share of output, which in this model is $\alpha\theta$, below 0.4.

2.2 Country B (flexible-wages)

The structure of the economy of this country is similar to country A, except for the labour market. We assume a perfectly competitive labour market with equilibrium at the full employment level, given by the exogenous

[12] See, Basu and Fernald (1997) and Burnside (1996), which show evidence on values that can be positive but close to zero.

labour supply, since we disregard the existence of disutility of labour in this economy.[13] In this case, (symmetric) equilibrium in the labour market is reached when real wages are identical to the marginal productivity of labour at $l_{B,t} = N_B/m \equiv n_B$. Obviously, in this economy the interest factor, i.e., the real rental cost of capital, is given by the marginal productivity of capital,

$$\theta \mathcal{A} k_{B,t}^{v+\theta-1} n_B^{1-\theta} = r_{B,t}.$$

It is, then, possible to summarise the equilibrium dynamics for this economy by a first-order difference equation, namely the capital accumulation equation $k_{B,t+1} = w_{B,t} n_B$. Substituting wages by the marginal productivity of labour yields,

$$k_{B,t+1} = (1-\theta)\, \mathcal{A} k_{B,t}^{v+\theta} n_B^{1-\theta}.$$

The steady state level of capital is $k_B = \left[(1-\theta)\, \mathcal{A} n_B^{1-\theta}\right]^{\frac{1}{1-(v+\theta)}}$.

Since capital is a predetermined variable, there is no indeterminacy. Moreover, the equation above is loglinear, implying that all equilibrium trajectories either converge to the steady state (if $\theta + v < 1$), or become explosives ($\theta + v > 1$). Indeed, note that this economy would exhibit endogenous growth if $\theta + v > 1$, a case that we shal disregard.

We shall assume that the social marginal productivity of capital is a decreasing function, i.e., $\theta + v < 1$, a requirement compatible with (8). Hence, the steady state is a stable equilibrium.

Proposition 2 *Consider $\theta + v < 1$. Then, under autarky the flexible-wage economy converges to a stable determinate steady state.*

Since we assume that (8) is always verified, i.e., a requirement compatible with $\theta + v < 1$, country B does not exhibit indeterminacy at the autarkic equilibrium.

[13] The utility function of a young agent born in period t is simply given by c_{t+1}.

3 Equilibrium with free trade and free international capital movements

Free trade implies that output prices are identical in both countries. Also, liberalisation of capital movements between both countries implies that interest rates become identical. Hence, at equilibrium, the world capital stock, available for production in every period t, must be distributed among firms of both countries in a way such that,

$$\begin{aligned} k_t &= k_{A,t} + k_{B,t} \\ \alpha\theta\mathcal{A}k_{A,t}^{v+\theta-1}l_{A,t}^{1-\theta} &= \theta\mathcal{A}k_{B,t}^{v+\theta-1}n_B^{1-\theta} = r_t. \end{aligned}$$

These equations can be used to obtain the level of capital rented by a representative firm in each country, $k_{A,t}$ and $k_{B,t}$, as a function of k_t and $l_{A,t}$

$$k_{A,t} = k_t \frac{1}{1+z_t} \tag{9}$$

$$k_{B,t} = k_t \frac{z_t}{1+z_t}, \tag{10}$$

where,

$$z_t = \left[\alpha\left(\frac{l_{A,t}}{n_B}\right)^{1-\theta}\right]^{\frac{1}{v+\theta-1}}. \tag{11}$$

Capital accumulation in the world is driven by the sum of wage income in both countries, $k_{t+1} = w_{A,t}l_{A,t} + w_{B,t}n_B$. Since there is no change in the labour market structure with respect to the autarkic situation, wages in country A are given as under autarky and wages in country B are still equal to the marginal productivity of labour. Using the above expressions for $k_{A,t}$ and $k_{B,t}$ into the world capital accumulation equation, we obtain the first of the two dynamic equations definining the equilibrium system of this world economy, as a function of the world capital level, k, and employment in country A, l_A,

$$k_{t+1} = \mathcal{A} k_t^{\theta+v} \left[(1-\theta\alpha)\, l_{A,t}^{1-\theta} \left(\frac{1}{1+z_t} \right)^{\theta+v} + (1-\theta)\, n_B^{1-\theta} \left(\frac{z_t}{1+z_t} \right)^{\theta+v} \right]. \tag{12}$$

The other dynamic equation is obtained by using the employment equilibrium condition for country A, stating that $\bar{w}_t = a/\ r_{t+1}$, where as in (2), $\bar{w}_t = (1-\theta)\, \mathcal{A} k_{A,t}^{v+\theta} l_{A,t}^{-\theta}$, and r_{t+1} is the world interest factor whose expression is given above. Using (9), we then obtain,

$$(1-\theta)\, \mathcal{A} k_t^{v+\theta} \left(\frac{1}{1+z_t} \right)^{v+\theta} l_{A,t}^{-\theta} = a/\{\alpha\theta \mathcal{A} k_{t+1}^{v+\theta-1} l_{A,t+1}^{1-\theta} \left(\frac{1}{1+z_{t+1}} \right)^{v+\theta-1} \}. \tag{13}$$

Equations (12) and (13) describe the dynamic equilibria of our model written in terms of the predetermined variable k, whose value is determined by the world past savings, and by the non-predetermined variable l_A, whose value is again influenced by current expectations of future rental rates.[14]

Using (11) and substituting k_{t+1} in (13) by its value, as given in expression (12), we obtain a two dimensional non linear dynamic map $(k_{t+1}, l_{A,t+1}) = G\ (k_t, l_A)$ which can be implicitly written as follows

$$k_{t+1} = \mathcal{A} k_t^{\theta+v} l_{A,t}^{1-\theta} \frac{X_t}{H_t^{\theta+v}} \tag{14}$$

$$l_{A,t+1}^{\theta-1} H_{t+1}^{v+\theta-1} = (1-\theta)\, (\alpha\theta/a)\, \mathcal{A}^{v+\theta+1} k_t^{(\theta+v)^2} l_{A,t}^{(1-\theta)(v+\theta)-1} \frac{X_t^{v+\theta-1}}{H_t^{(\theta+v)^2}}, \tag{15}$$

where H and X are both functions of l_A (through z as given in (11)),

$$X_t = (1-\theta\alpha) + (1-\theta)\, \alpha z_t$$

[14]Note that, although k is predetermined, k_A and k_B are non-pretermined variables, since their values are influenced by employment in country A (cfr. equations (9)-(11)).

$$H_t = 1 + z_t.$$

Note that, by use of (9), (10), (11) and (3), and recalling that wages in country B are given by the marginal productivity of labour at full employment, country B saving share of world savings is given $w_B n_B/(w_A l_{A+} w_B n_B) = (1-\theta)\alpha z_t/X_t$. Whereas, by use of (11), country B capital (used in the production process) share of world capital is given by $k_{B,t}/k_t = z_t/H_t$. For later use, we compute the elasticity of X and H with respect to l_A

$$\frac{d\ln X}{d\ln l_A} = \frac{1-\theta}{\theta+v-1} s^s_{B,t}\ , \quad s^s_{B,t} \equiv \frac{w_B n_B}{w_A l_{A+} w_B n_B} = (1-\theta)\alpha z_t/X_t \tag{16}$$

$$\frac{d\ln H}{d\ln l_A} = \frac{1-\theta}{\theta+v-1} s^k_{B,t}\ , \quad s^k_{B,t} \equiv k_{B,t}/k_t = z_t/H_t \tag{17}$$

where $s^s_{B,t} \in (0,1)$ and $s^k_{B,t} \in (0,1)$.

A steady state (k,l) for the system (14) and (15) must satisfy,

$$\frac{H^{\theta+\nu}}{X l_A^{1-\theta}} k^{\theta+\nu-1} = \mathcal{A}$$

$$(1-\theta)\alpha\theta\mathcal{A}^{\theta+\nu+1} k^{(\theta+\nu)^2} \frac{X^{\theta+\nu-1}}{H^{(\theta+\nu)^2-(\theta+\nu-1)}} l_A^{(\theta+\nu-1)(1-\theta)-1} = a$$

The existence of a given $(k,\, l_A)$ will be ensured by assuming that the scale parameters $(\mathcal{A},\, a)$ take appropriate values.

For later reference, note that the ratio s^s_B/s^k_B, evaluated at the steady state, is given by $(1-\theta)\alpha H/X$ which, by use of the expressions for H and X given above, reads as,

$$\frac{s^B_s}{s^B_k} = \frac{(1-\theta)\,\alpha + (1-\theta)\,\alpha z}{(1-\theta\alpha) + (1-\theta)\,\alpha z} \leq 1 \Longleftrightarrow \alpha \leq 1. \tag{18}$$

Condition (18) means that, in country B, the amount of capital goods used in production is higher or equal than investment in capital goods through

savings, i.e., $s_k^B - s_s^B \geq 0$. Therefore, at the steady state, either there are no exports or imports of capital (the case of $\alpha = 1$), or country B is a net capital importer (the case of $\alpha < 1$). However, as discussed below, there are equilibrium trajectories along which, from one period to the other, capital flows between countries are reversed.

The local stability analysis will be conducted by using the linear map associated with the Jacobian matrix, evaluated at the steady state, of the system (14)-(15).[15] The matrix J is given as follows

$$J = \begin{bmatrix} \theta + v & (1-\theta) + \frac{d\ln X}{d\ln l_A} - (\theta+v)\frac{d\ln H}{d\ln l_A} \\ \frac{(\theta+v)^2}{(\theta-1)+(\theta+v-1)\frac{d\ln H}{d\ln l_A}} & \frac{[(1-\theta)(v+\theta)-1]+(v+\theta-1)\frac{d\ln X}{d\ln l_A}-(\theta+v)^2\frac{d\ln H}{d\ln l_A}}{(\theta-1)+(\theta+v-1)\frac{d\ln H}{d\ln l_A}} \end{bmatrix}, \tag{19}$$

with $\frac{d\ln X}{d\ln l_A}$ and $\frac{d\ln H}{d\ln l_A}$ given, respectively, as in (16) and (17) and where the shares s_s^B and s_k^B are both evaluated at the steady solution under study. Trace and determinant of J are equal to,

$$T = \frac{[1-(\theta+v)]\left[1-(1-\theta)\,s_s^B\right] - (\theta+v)(1-\theta)\,s_k^B}{[1-(\theta+v)](1-\theta)(1-s_k^B)}$$

$$D = \frac{(\theta+v)[1-(\theta+v)] - (\theta+v)(1-\theta)\,s_s^B}{[1-(\theta+v)](1-\theta)(1-s_k^B)}.$$

Assuming that (8) is satisfied we obtain that,

$$D > T-1 \Leftrightarrow [1-2(\theta+v)]\left(s_k^B - s_s^B\right) < \frac{v[1-(\theta+v)]}{1-\theta} \tag{20}$$

$$D < 1 \Longleftrightarrow s_k^B < \frac{(1-2\theta)-v}{1-\theta} + \frac{\theta+v}{1-(\theta+v)}s_s^B \tag{21}$$

$$D > -T-1 \Longleftrightarrow s_k^B < \frac{[1-(\theta+v)](2+v)}{1-\theta} - s_s^B. \tag{22}$$

[15] Hartman Grobman theorem.

It is then easy to check that, given (8) and (18), indeterminacy arises if and only if the following parameter configuration is satisfied,

$$0 < s_s^B < \frac{[1-(\theta+v)](2+v)}{2(1-\theta)} \tag{23}$$

$$0 \leq s_k^B - s_s^B < Min\{\Psi_1, \Psi_2, \Psi_3\}, \tag{24}$$

where,

$$\begin{aligned}
\Psi_1 &\equiv \frac{[1-(\theta+v)]v}{[1-2(\theta+v)](1-\theta)} \\
\Psi_2 &\equiv \frac{(\theta+v)v}{(1-\theta)[1-(\theta+v)]} + \frac{[1-2(\theta+v)]}{[1-(\theta+v)]}\left(1-s_s^B\right) \\
\Psi_3 &\equiv \frac{[1-(\theta+v)](2+v)}{(1-\theta)} - 2s_s^B.
\end{aligned}$$

Note that, since by (18), $s_k^B - s_s^B \geq 0$, for (24) to hold the expressions defined above, Ψ_1, Ψ_2, Ψ_3, must be positive, which is true under (8) and (23). Condition (24) ensures that (20) to (22) are also satisfied.[16]

Condition (23) sets an upper bound for savings in country B as a share of world savings. Condition (24) sets an upper bound for country B capital imports share of world savings, i.e., for $s_k^B - s_s^B$. This seems to be a reasonable condition, since we may expect free capital movements to exist as long as the capital importing country sustains its balance of payments imbalance.

[16] We may note that if $s_k^B - s_s^B > \Psi_2$ then $D > 1$ and the steady state would be a source. In this case trajectories for the state variables would become explosive or they could become bounded by an invariant closed curve. Indeed, note that the system is no longer linear and bifurcations may occur. If a supercritical Hopf bifurcation occurs, it would mean that a stable invariant closed curve generically appears, at least for values of D higher than but close to 1. If explosiveness was not avoided before l_A reaches n_A then the system would experience a change of regime, since in country A labour demand would be constrained.

As noted before, the condition $s_k^B - s_s^B \geq 0$ does not allow country B to be a net exporter of capital at the steady state.[17] However, *indeterminacy* of the steady state implies the existence of infinitely many stochastic endogenous fluctuations around the steady state, driven by self-fulfilling volatile expectations, along which capital flows between countries can be reversed. Indeed, depending on expectations of future interest rates, country A and country B can be either net importer or net exporter of capital. More precisely, a decrease in the *expected* interest rate induces country A (country B) to export capital (to import capital), while an increase in the *expected* interest rate induces country A (country B) to import capital (to export capital). Consider, for example, a decrease in the *expected* interest rate. This will increase the reservation wage and will have an immediate negative effect on the level of employment in country A. The latter, by means of (4), will induce a decrease in the *current* interest rate of country A leading to capital outflows towards country B. By a similar argument one can see how an expected increase in interest rates leads to capital outflows from country B.

Let us now discuss the influence of union bargaining power, $(1-\alpha)$, on the conditions that lead to indeterminacy when externalities, ν, take values close to zero, which is the most relevant configuration from an empirical point of view. First, note that if labour markets were perfectly competitive also in country A, that is, if unions have no bargaining power, then, $\alpha = 1$, and, by use of (18), $s_B^s - s_B^k = 0$, implying that conditions (20) and (21) are always verified.[18] Hence, the steady can only be saddle point stable if $D < -T - 1$ implying that $s_B^k - s_B^s = 0 > \Psi_3$ This condition can only be fulfilled when $1 > s_s^B > \frac{[1-(\theta+v)](2+v)}{2(1-\theta)}$, which can not be satisfied when ν is arbitrarily small since, in this case, the $\lim_{\nu \to 0} \frac{[1-(\theta+v)](2+v)}{2(1-\theta)} = 1$. Therefore, indeterminacy in

[17] Note that it is the difference in the labour market structure that drives the existence of capital movements at the steady state. If both countries shared the same marginal disutility of labour, a, and the same unions bargaining power, α, then they would have the same amount of employment and capital at equilibrium. Moreover, in this case, under free capital movements and, therefore, identical interest rates in both countries, the reservation wage would be the same and adding free labour mobility would not make any difference. The equilibrium system would be similar to the one presented for the autarkic equilibrium in country A, where $k_{A,t}$ should be substitued by k_t. The local stability properties would be the same and, therefore, the liberalization of capital movements would not bring new results with respect to indeterminacy.

[18] Indeed, condition (20) would become $1 - (\theta + \nu)\nu/(1 - \theta) > 0$, which is ensured by (8). Condition (21) is equivalent to $s_B^k - s_B^s < \Psi_2$, which is verified since $s_B^k - s_B^s = 0$, and $\Psi_2 > 0$ under (8) and $0 < s_B^s < 1$.

world markets is very likely to appear when labour markets are perfectly competitive. In the Appendix it is shown that the same conditions apply when there are efficiency wages. The following proposition summarises this result.

Proposition 3 *Assume that condition (8) holds and capital externalities are arbitrarily small. Then, if in Country A the labour market is perfectly competitive, or if there are efficiency wages, the world economy exhibits equilibrium indeterminacy under perfect capital mobility.*

If in country A there are unions ($\alpha < 1$), the steady state is saddle point stable when: (i) condition (23) and $\Psi_1 < s_k^B - s_s^B < \Psi_3$ are satisfied, ensuring that $D < T - 1$ and $D > -T - 1$; or, when $D > T - 1$ and $D < -T - 1$, which is ensured by (ii) $1 > s_s^B > \frac{[1-(\theta+v)](2+v)}{2(1-\theta)}$ and $0 < s_k^B - s_s^B < \Psi_1$, or by (iii) $\Psi_3 < s_k^B - s_s^B < \Psi_1$ and (23). As stressed before, (ii) is likely not to be fulfilled. Also, (iii) is not feasible for ν arbitrarily small since $\lim_{\nu \to 0} \Psi_1 = 0$. However, configuration (i) may occur. Indeed, configuration (i) is verified for arbitrarily small values of ν, since $\lim\limits_{\nu \to 0} \Psi_1 = 0$ and $\lim\limits_{\nu \to 0} \Psi_3 = 1 - s_s^B$. Therefore, $\Psi_1 < s_k^B - s_s^B < \Psi_3$ reads as $s_k^B < 1$, when ν tends to zero, which is always verified; and, $s_k^B - s_s^B > 0$, which (by (18)) is always verified when $\alpha < 1$. Hence, under arbitrarily small capital externalities and unionised labour market in country A, determinacy in the world markets occurs. The next proposition restates the result.

Proposition 4 *Assume that condition (8) holds and capital externalities are arbitrarily small. Then, if in country A there are labour unions and capital is perfectly mobile, the world economy exhibits equilibrium determinacy.*

The result that equilibrium indeterminacy is more likely under perfect competition (or efficiency wages) in labour markets can be rationalised as follows. Suppose that agents in country A expect a decrease in tomorrow's interest rate, for this change in expectations to become self-fulfilled world savings, i.e. the world wage bill, should increase, so that an increase in capital accumulation, to be used in production next period, can support a decrease in r_{t+1}.[19]

[19] Recall that r is positively related to the marginal productivity of capital which, in turn, is decreasing in k, under assumption (8).

When expectations of future interest rate decrease, the reservation wage increases and employment in country A decreases which, in turn, decreases the wage bill in country A. At the same time, the decrease in employment in country A decreases the rate of return to capital in country A. Capital flows out from country A to country B. This leads to an increase in the wage bill in country B and to a decrease in the wage bill in country A. Due to the inflow of capital, the marginal productivity of labour (wages) in country B increases, implying a higher wage bill. In country A, the capital outflow decreases the marginal productivity of labour, producing a further decrease in employment. As a consequence, the wage bill in country A decreases not only due to the decrease in capital but also due to the induced decrease of employment. Indeed, using (3) the wage bill in country A can be written as $(1-\theta)\mathcal{A}k^{\nu+\theta}l_A^{1-\theta} + (1-\alpha)\theta\mathcal{A}k^{\nu+\theta}l_A^{1-\theta}$, which is an increasing function of k and l_A. Note, also, that, when unions have some bargaining power ($\alpha < 1$), wages are set above the marginal productivity of labour, hence employed workers earn an extra income with respect to the case of perfect competition or efficiency wages, i.e., $(1-\alpha)\theta\mathcal{A}k^{\nu+\theta}l_A^{1-\theta}$. The latter term represents the fraction of the rents from investment appropriated by the workers. This also decreases when k and l_A decrease, implying that workers in country A suffer a relatively larger income loss than under perfect competition or efficiency wages. Hence, we may expect that, when expectations of future interest rates decrease, the wage bill in country A decreases more when $\alpha < 1$ than when $\alpha = 1$, rendering more difficult an increase in world savings.

To sum up the main results of this section, we have shown that, under plausible restrictions on the fundamentals, a country that exhibits indeterminacy under autarky may 'export instability' to the rest of the world, and to an otherwise determinate economy, when free capital movements and free trade are allowed. This happens when in both countries wages are identical to the marginal productivity of labour, i.e., when labour markets are perfectly competitive or when there are efficiency wages. However, free trade and capital mobility may also bring determinacy to a country that would exhibits indeterminacy under autarky. This happens when workers in the country that exhibits indeterminacy under autarky appropriate part of the investment rents, i.e., when labour unions have some bargaining power and wages are set above the marginal productivity of labour.

4 Integrated Equilibrium: migration conditional on a work contract

Here we consider that, besides free trade and free capital mobility between countries, free international mobility of workers is allowed. We assume that a young agent can only migrate if he/she is able to get employment in the host country. Therefore, since, as before, we assume the possibility of unemployment in country A, young natives from B can only stay in A if they are able to get employment there. Otherwise they are repatriated.[20] We assume that, if repatriated, workers can still find a job in their original country B, so that the world labour force remains constant over time. Unions in country A bargain with firms in order to get a certain level of employment per firm, $l_{A,t}$, taking as given the number of young residents, without distinguishing by their origin.[21] Therefore, employment and wages in country A, at an intertemporal equilibrium, are still given as in equations (2) and (3), together with (1). In country B wages are still given by the marginal productivity labour. To simplify we ignore the travel costs of migration.

Workers are willing to migrate as long as this is an alternative that brings an incremental value in terms of expected utility (consumption in their old age). Let $mn^*_{A,t}$ be the number of young households living in country A at time t. Unemployment in country A means that $l_{A,t} < n^*_{A,t}$. Therefore, the probability of getting a job in country A is $l_{A,t}/n^*_{A,t}$. A native worker from country B wishes to migrate to country A when: $w_{B,t} < (l_{A,t}/n^*_{A,t})w_{A,t} + (1 - l_{A,t}/n^*_{A,t})w_{B,t} \Leftrightarrow w_{B,t} < w_{A,t}$. Here, we shall focus on equilibria where in the labour force of each country there are some natives, and where there exists some immigration in country A. To ensure this, we assume that natives from B can never get full citizenship in country A, so that their descendants can only have a permit of residence in country A if they are also able to get a job. Therefore, a decendant of a native from B living in A is willing to move to country B if $w_{B,t} > (l_{A,t}/n^*_{A,t})w_{A,t} + (1 - l_{A,t}/n^*_{A,t})w_{B,t} \Leftrightarrow w_{B,t} > w_{A,t}$.

Equilibrium within each period requires that no further worker movements are observed; hence, equilibrium requires that $w_{A,t} = w_{B,t}$, i.e.,

[20] A repatriate is someone who ends up in his/her home country not because he/she has chosen that option but because he/she could not get employment abroad.

[21] Since unemployed native workers from B are repatriated, all those unemployed in country A are natives from A. Therefore, the assumption that unions' members are either employed, receiving a wage w_A, or unemployed is satisfied at equilibrium.

$$(1-\theta\alpha)\, k_A^{\theta+v} l_A^{-\theta} = (1-\theta)\, k_B^{\theta+v} l_B^{-\theta}.$$

Given perfect capital mobility, equations (9), (10) and (11) are still valid if we substitute n_B with $l_{B,t}$. Using (9) and (10) we obtain,

$$(1-\theta\alpha)\, l_{A,t}^{-\theta} = (1-\theta)\, l_{B,t}^{-\theta} z_t^{\theta+v}.$$

Using (11) to substitute for z_t yields

$$l_{B,t} = h.l_{A,t}\,, \tag{25}$$

where $h \equiv \frac{(1-\theta\alpha)}{(1-\theta)} \alpha^{\frac{1}{1-v-\theta}} \left[\frac{(1-\theta\alpha)}{(1-\theta)} \alpha^{\frac{1}{1-v-\theta}}\right]^{\frac{1-\theta-v}{(1-\theta)^2+\theta v}}$. Using this expression in (11), we obtain a value for z constant over time, i.e.,

$$z = \left(\frac{h^{1-\theta}}{\alpha}\right)^{\frac{1}{1-v-\theta}}. \tag{26}$$

The capital accumulation equation is now given by: $k_{t+1} = w_{A,t}(l_{B,t}+l_{A,t})$. Using (3) and (9) and the expression above, $l_{B,t} = h.l_{A,t}$, yields to,

$$k_{t+1} = \frac{(1-\theta\alpha)}{(1+z)^{\theta+v}} \mathcal{A} k_t^{\theta+v} l_{A,t}^{1-\theta}. \tag{27}$$

Notice that natives from A working in country B have no incentive to move back to their own country. Indeed, this would happen if $w_{B,t} < (l_{A,t}/n^*_{A,t}) w_{A,t} + (a/r_{t+1})(1 - l_{A,t}/n^*_{A,t})$, which, under $w_{A,t} = w_{B,t}$ and (1), would imply $w_{A,t} < (a/r_{t+1}) \equiv \overline{w_t}$. However, this is impossible at equilibrium since it contradicts conditions (2) and (3).

Also, natives from A working in their own country have no incentives to move to country B, as long as $w_{A,t} = w_{B,t}$.

Lastly, we need to analyse the case of natives of A living in their own country and possibly unemployed. This people have an incentive to move to country B if $w_{B,t} > (a/r_{t+1})$ which, under $w_{A,t} = w_{B,t}$ and (1), leads to $w_{A,t} >$

$\overline{w_t}$. By direct inspection of (2) and (3) it can be seen that, if $\alpha = 1$ (no unions, nor efficiency wages), $w_{A,t} > \overline{w_t}$ is never satisfied. Hence, unemployed have no incentive to move. If, instead, $\alpha < 1$, conditions (2) and (3) imply that $w_{A,t} > \overline{w_t}$ always hold, and all unemployed will move to country B. Therefore, an equilibrium with $w_{A,t} = w_{B,t}$ requires full employment in country A.

The latter consideration implies that the equilibrium dynamics will differ depending on α equal or lower than one.

Consider first the case of $\alpha = 1$, i.e., perfectly competitive labour markets in country A. Given (1), (2), (3) and (4) the following must hold at equilibrium

$$\frac{a}{\theta \mathcal{A} k_{A,t+1}^{\nu+\theta-1} l_{A,t+1}^{1-\theta}} = (1-\theta)\mathcal{A} k_{A,t}^{\nu+\theta} l_{A,t}^{-\theta},$$

which, by use of (9), reads as

$$\frac{a}{\theta \mathcal{A} \left(k_{t+1}\frac{z}{1+z}\right)^{\nu+\theta-1} l_{A,t+1}^{1-\theta}} = (1-\theta)\mathcal{A}\left(k_t \frac{z}{1+z}\right)^{\nu+\theta} l_{A,t}^{-\theta},$$

where z, as defined in (26), takes the value 1 when $\alpha = 1$. By substituting (27) into the above expression we obtain

$$l_{A,t+1} = g k_t^{-(v+\theta)^2/(1-\theta)} l_{A,t}^{-\left(v+\theta-1-\frac{\theta}{1-\theta}\right)}, \tag{28}$$

where $g \equiv \left[\frac{(a/\theta)2^{(v+\theta)(1+\nu+\theta)-1}}{(1-\theta)^{(v+\theta)}\mathcal{A}^{(1+v+\theta)}}\right]^{1/(1-\theta)}$.

The expressions in (28) and (27) define the equilibrium dynamics in terms of k and l_A when $\alpha = 1$. It can be easily checked that the equilibrium dynamic system is log-linear and similar, up to some multiplicative constants, to the autarkic equilibrium in country A. Therefore, the conditions for world indeterminacy in the case of integrated equilibrium with perfectly competitive labour markets coincide with those for the autarkic equilibrium in country A. Hence, country A exports indeterminacy to the world markets. The following proposition summarises.

Proposition 5 *Assume $0 < \theta < \frac{1}{2}$ and $0 < v < 1 - 2\theta$. Then, under perfect competition in country A's labour market and perfect mobility of capital and labour, the economy exhibits equilibrium indeterminacy.*

As noticed previously, if agents in country A expect a decrease in future interest rates, the immediate effect is a decrease in employment of country A. Wages in country A would increase and interest rates would fall. Given the existence of free factor movements it is, then, likely that this will induce capital flows from counry A to country B and migration flows in the opposite direction. Both movements help and reinforce the re-establishment of the no arbitrage conditions for wages[22] and interest rates. The fact that labour movements reinforce the effects of capital movements on interest rates may be an additional contribution to the occurrence of indeterminacy.

Turning now to the case of imperfectly competitive labour market in country A, i.e., $\alpha < 1$, since, as discussed before, in this case there is no unemployement at the world level, the following must hold

$$l_{A,t} + l_{B,t} = n, \tag{29}$$

where $n \equiv \frac{N_A + N_B}{m}$.

By use of (25) and (29) we obtain the level of employment in country A and country B, in every period, as a given share of world population, i.e.,

$$\begin{aligned} l_{A,t} &= \frac{1}{1+h} n \\ l_{B,t} &= \frac{h}{1+h} n. \end{aligned} \tag{30}$$

From (30) and (27) we, then, obtain the following equilibrium capital accumulation equation,

$$k_{t+1} = \frac{(1-\theta\alpha)}{(1+z)^{\theta+v}} \left(\frac{1}{1+h} n \right)^{1-\theta} \mathcal{A} k_t^{\theta+v}. \tag{31}$$

The expression in (31) defines the equilibrium dynamics (for $\alpha < 1$) in

[22] Although these movements do not change wages in country A, as they are pegged to the reservation wage, they do affect wages in country B.

terms of the predetermined variable k.[23] It can be easily checked that, the equilibrium dynamic system above is log-linear and similar, up to some multiplicative constants, to the autarkic equilibrium in country B. Therefore, the steady state is a determinate stable equilibrium when $\theta+v<1$, which is verified under assumption (8). As a consequence, country B exports determinacy to the world markets. In the Appendix it is shown that the same conditions apply when there are efficiency wages. These findings are summarised in the following proposition.

Proposition 6 *Assume $\theta+v<1$. Then, under imperfect competition in country A's labour market and perfect mobility of capital and labour, the economy converges to a stable determinate steady state with full employment.*

The difference between the last two propositions can be understood as follows. A negative shock to expectations about future interest rates has the same, immediate, effect on country A as before; namely, inducing capital flows from country A to country B and migration flows in the opposite direction. However, the decrease in employment in country A implies that some natives from country A becomes unemployed. As long as $\alpha<1$, unemployed have an incentive to move to country B since $w_{B,t}>\frac{a}{r_{t+1}}\equiv\overline{w_t}$. These movements of unemployed counteract the initial effects of capital and workers' movements on interest rates and wages, which may explain why now indeterminacy cannot occur. Note that, unemployed workers in country A will be willing to move only if their expected salary is above their reservation wage, which implies, in turn, that currently employed workers in country A are payed a wage above the competitive level. Hence, free trade and free factor movements, coupled with wage rigidities in one country, may bring both macroeconomic stability and full employment at the world level.

5 Conclusions

In this paper we have developed a dynamic two-country model where the source of cross-country heterogeneity lies in labour market institutions. We

[23] Note that we, also, must verify that $w_{B,t}=w_{A,t}>\frac{a}{r_{t+1}}\equiv\overline{w_t}$ holds at equilibrium. By appropriate choice the (exogenous) world population level, n, and of the scale parameters a and $\mathcal{A}$, we can ensure that the above condition is satisfied. Hence, a (small) change, around the steady state, of expectations about future interest rates do not influence equilibrium. Since wages do not change, there is no incentive for labour movements. Therefore, employment in both countries remain the same and, also, interest rates do not change.

have focussed our attention on the issue of factor mobility and derived two main results. First, free capital movements, coupled with labour immobility, implies that the rigid-wage country may export instability to the rest of the world. Hence, the flexible-wage country may also experience output fluctuations. However, such a macroeconomic instability is less likely to occur when workers in the rigid-wage country are unionised. In our model, equilibrium indeterminacy in world markets implies that capital flows between countries can be reversed, i.e., depending on expectations of future interest rates each country can be either a net importer or a net exporter of capital. When workers in the rigid-wage country are unionised they appropriate part of the investment rents, and changes in expected interest rates affect their earnings by more than if wages were set under perfect competition (or efficiency wages), thereby, reducing the chance of appearance of equilibrium output fluctuations. Second, under both capital and labour mobility, changes in expectations of future interest rates in one country affect the other through no arbitrage conditions on both interest rates and wage rates. When labour markets are perfectly competitive it turns out that labour movements reinforce the effects of capital movements on interest rates, making equilibrium indeterminacy very likely to occur. If, on other hand, there are wage rigidities and unemployement in one country the world economy may acheive stability and full employment. In this case, unemployed workers living in the rigid-wage country will be willing to move to the flexible-wage country since they anticipate a salary above their reservation wage (via the no arbitrage condition in the labour market). To conclude, our results suggest that, in an integrated world with free capital and labour movements, wage rigidities (such as unions or efficiency wages) are not harmful. On the contrary, they may prevent macroeconomic fluctuations at the world level. Absent labour mobility, free trade and capital movements can be accompained by macroeconomic fluctuations at the world level, particularly when workers are unable to extract investment rents.

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Appendix: Efficiency wages in country A

Here, we consider a simplified version of the model used by Coimbra (1999). We assume that workers are risk neutral, as in Section 2.1 above. Accordingly, a worker born in period t has a utility function $c_{A,t+1} - a.e_t$, where effort, e, can only take two values: $e = 0$ if no effort is supplied and $e = 1$ if the worker is employed and does not shirk. In each period, t, employed workers receive a wage $w_{A,t}$, which is saved for future consumption through investment in productive capital goods rented to firms in the next period, implying $c_{A,t+1} = w_{A,t}r_{A,t+1}$. If a worker is caught shirking is fired. However, employers can only imperfectly monitor workers. The monitoring technology is not made explicit, we simply assume that the ex-ante probability of shirking without being caught is given by $1 < \varphi < 0$. Obviuously, $\varphi = 0$ corresponds to the case of perfect monitoring. The indirect utility of a worker is, then, given as follows,

$$V = \begin{array}{ll} w_{A,t}r_{A,t+1} - a, & if\ not\ shirking \\ \varphi w_{A,t}r_{A,t+1}, & if\ shirking \\ 0, & if\ not\ working \end{array} .$$

Hence, when $(1-\varphi)w_{A,t}r_{A,t+1} \geq a$ employed workers have no incentives to shirk. Firms choose w_A, l_A and k_A such that profits are maximised. Each firm has a production function given by $\mathcal{A}\bar{k}^v_{A,t}k^\theta_{A,t}l^{1-\theta}_{A,t}$, where l_A is the number of workers employed and not shirking. The output of a worker who shirks is zero. Hence, the positive wage payed by firms should be such that it induces workers not to shirk. Accordingly, the problem soved by the firm is the following,

$$\underset{w_{At},l_{At},k_{At}\in\Re^3_{++}}{Max} \left(\mathcal{A}\bar{k}^v_{A,t}k^\theta_{A,t}l^{1-\theta}_{A,t} - w_{A,t}l_{A,t} - r_{A,t}k_{A,t}\right)$$

$$s.t.\ (1-\varphi)w_{A,t}r_{A,t+1} \geq a.$$

Obviously the incentive compatibility constraint is binding and, therefore, from the first order conditions we obtain that,

$$\theta A\bar{k}^v_{A,t}k^{\theta-1}_{A,t}l^{1-\theta}_{A,t} = r_{A,t}$$

$$(1-\theta)\, A\bar{k}_{A,t}^{v} k_{A,t}^{\theta} l_{A,t}^{-\theta} = w_{A,t}$$

$$\frac{a}{(1-\varphi) r_{A,t+1}} = w_{A,t}.$$

If $\varphi = 0$, these expressions coincide with expressions (4), (3) and (2) when $\alpha = 1$. Therefore, under efficiency wages and perfect monitoring of workers' effort, the same results as those obtained under the hyphotesis of a perfectly competitive labour market apply.

If $\varphi > 0$, firms pay a wage above the reservation wage, $w_{A,t}/\bar{w}_{A,t} = 1/(1-\varphi)$, as in the case of unions ($\alpha < 1$). However, employment is such that wages are identical to the marginal productivity of labour and the rental rate is given by the marginal productivity of capital, as in the case of a perfectly competitive labour market ($\alpha = 1$). Therefore, the dynamic system with efficiency wages and imperfect monitoring is not completely identical to the case studied in the main text with unions.

For the *autarkic solution* we obtain:

$$k_{A,t+1} = (1-\theta)\, \mathcal{A} k_{A,t}^{v+\theta} l_{A,t}^{1-\theta}$$

$$l_{A,t+1} = \overline{b} k_{A,t}^{-(v+\theta)^2/(1-\theta)} l_{A,t}^{-\left(v+\theta-1-\frac{\theta}{1-\theta}\right)},$$

where $\overline{b} \equiv \left[\frac{a}{(1-\varphi)\theta(1-\theta)^{(v+\theta)}\mathcal{A}^{(1+v+\theta)}}\right]^{1/(1-\theta)}$.

We can see that these expressions still give a loglinear dynamic system in k and l, and differ from (5) and (6) only by a multiplicative constant. Therefore, the local dynamic properties under efficiency wages are the same as under labour unions, and Proposition 1 applies also to the case of efficiency wages and imperfect monitoring.

For the case of free trade and *free capital mobility*, following the same procedure outlined in Section 3, we have that,

$$k_{t+1} = \mathcal{A} k_t^{\theta+v} l_{A,t}^{1-\theta} \frac{X_t}{H_t^{\theta+v}}$$

$$l_{A,t+1}^{\theta-1} H_{t+1}^{v+\theta-1} = (1-\varphi)(\theta/a)\mathcal{A}^{v+\theta+1} k_t^{(\theta+v)^2} l_{A,t}^{(1-\theta)(v+\theta)-1} \frac{X_t^{v+\theta-1}}{H_t^{(\theta+v)^2}}$$

where $X = (1-\theta)H$, $H = 1+z$ and $z = \left(\frac{l_{A,t}}{n_B}\right)^{\frac{1-\theta}{v+\theta-1}}$.

Note that these expressions correspond to (14) and (15) for the case of no unions ($\alpha = 1$), with the exception of the multiplicative constant in the dynamic equation for l_{t+1}. However, given the loglinearity of this equation, the local dynamic properties under efficiency wages are identical to the case of perfect competition studied in Section 3. Hence, Proposition 3 applies also to the case of efficiency wages and imperfect monitoring.

Lastly, if *all factors are mobile*, following the same steps as in Section 4, we get, $l_A = l_B$, and the dynamic equation for k_{t+1} corresponds to,

$$k_{t+1} = \frac{(1-\theta)}{2^{\theta+v}} \mathcal{A} k_t^{\theta+v} l_{A,t}^{1-\theta}$$

When $\varphi > 0$, wages are set as a markup over the reservation wage. As a consequence unemployed workers in country A move to country B, and the world level of employment is n, implying that employment in country A is constant and given by $l_A = n/2$. Then, the dynamic system becomes unidimensional and is given by,

$$k_{t+1} = \frac{(1-\theta)}{2^{1+v}} \mathcal{A} k_t^{\theta+v} n^{1-\theta}$$

which is loglinear and differs from (27) only by a multiplicative constant.

Hence, Proposition 6 applies also to the case of efficiency wages and imperfect monitoring.

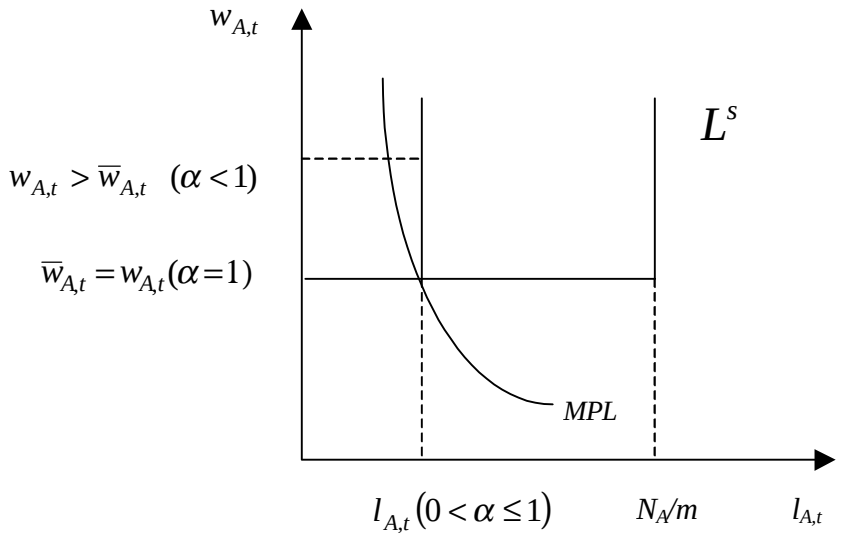

Figure 1: The labour market in the unionised economy