Unemployment Dynamics with International Capital Mobility*

Costas Azariadis
University of California, Los Angeles

Christopher A. Pissarides
Centre for Economic Performance,
London School of Economics and CEPR

May 2000

Abstract

We study the response of domestic unemployment rates to random impulses in total factor productivity for economies with relatively high capital mobility and relatively low labor mobility. We show that rapid capital movements across national borders, like those experienced by developed nations in the last twenty years, substantially amplify the impact on the domestic unemployment rate of domestic fluctuations in total factor productivity relative to what would have happened in a closed economy, shorten the duration of the responses and raise the variability of employment. Capital flows increase the riskiness of labor income and reduce the riskiness of capital income.

Keywords: unemployment, foreign direct investment, fluctuations, capital mobility

JEL Classification: E24, E32, F21, J64

*Work on this paper was made possible by a STICERD Fellowship to the first author at the London School of Economics. Without implications, we thank for their comments Ken Rogoff, Nobu Kiyotaki, Jean-Jacques Laffont, James Mirrlees, Kaare Petter Hagen, Lans Bovenberg, Tony Venables and Raquel Fernandez. We also thank Pablo Burriel-Llombart and Paloma Lopez-Garcia for research assistance.

1. Introduction

High unemployment has become a key domestic concern for developed countries at a time when their capital markets are increasingly integrated. The principal aim of this paper is to understand the response of domestic unemployment rates to random impulses in total factor productivity for economies with relatively high (physical) capital mobility and relatively low labor mobility. We are particularly interested in the dynamics of unemployment because we have reasons to suspect that rapid capital movements across national borders, like those experienced by relatively developed nations in the last twenty years, have important qualitative and quantitative consequences for the world distribution of jobs. Specifically, we find that perfect capital mobility substantially amplifies the impact on the domestic unemployment rate of domestic fluctuations in total factor productivity relative to what would have happened in a closed economy, shortens the duration of the responses, and raises the variability of employment. But it does not substantially affect the mean level of unemployment.

Nothing in this paper should be construed as an argument for economic policies restricting capital mobility. Like every classical economic structure, which trivially implies that removing barriers to factor mobility increases output, ours suggests that international capital flows enlarge the average gross national product everywhere. However, the mobility advantage of physical capital over labor has an important side effect: there are now bigger and sharper fluctuations in labor demand than one would observe in a closed economy. This side effect, which forms the core of our paper, implies that capital flows increase the riskiness of labor income and reduce the riskiness of capital income. This can lower the welfare of individuals who are primarily or exclusively invested in human capital.

The increasingly global nature of world capital markets seems to us to challenge both economic theory and economic policy. Theory needs to understand whether, and to what extent, capital flows contribute to unemployment. Policy needs to think of efficient mechanisms that reduce the side effects of international capital movements on undiversified labor income in the absence of perfect insurance markets, without giving up the obvious long-term benefits to output and aggregate consumption.

Why capital mobility amplifies productivity fluctuations is easiest to grasp if one thinks how a small fully-employed economy would adjust to a temporary and correctly-perceived reduction in its own total factor productivity while the TFP of every other nation remains unchanged. Domestic demand for both capital and labor would drop for one period, lowering both factor prices in the absence of international factor mobility. As a result of the ensuing recession, domestic savings fall and the capital-labor ratio initially shrinks but then converges to its steady state, following the recovery of national TFP and savings to their former level.

The situation worsens in an economy with capital mobility because capital ‡ows abroad when the adverse TFP shock hits, further shrinking labor demand and deepening the recession. On the plus side, capital imports accelerate the recovery to the steady state when productivity improves. We show that in a world with Cobb-Douglas utility and production functions, the implications of the mechanisms just described are to increase the variability of output and employment but not a¤ect the (unconditional) expected value of the logarithm of output or employment. At small unemployment rates, mean output is higher with international capital mobility but mean unemployment is about the same.

Section 2 is a formal statement of this intuition in a lifecycle model of savings with labor market matching. Unemployment in this model is an equilibrium outcome of costly job creation. Sections 3 and 4 study the dynamics of employment and unemployment in small and large economies where total factor productivity shocks are imperfectly correlated. Section 4, in particular, provides numerical examples of how capital mobility a¤ects the dynamic response of the unemployment rate to ‡uctuations in factor productivity, and gives some evidence from the OECD on recent trends in capital mobility and unemployment. We conclude with a discussion of some testable implications in section 5.

2. A Model of capital mobility and unemployment

This section outlines a fairly general model of a world economy in which temporary international di¤erences in total factor productivity drive capital movements across national boundaries and cause domestic unemployment rates to ‡uctuate with greater amplitude than would have been the case if capital were immobile. We begin with the working assumption that physical capital is homogeneous but completely immobile. Our next assumption is more questionable but, in our view, justified by our interest in economic fluctuations rather than in long-term growth: we suppose that countries may have different sizes but are otherwise identical. In particular, all households have identical tastes and endowments. In addition, every nation has, on average, the same technological possibilities in producing consumption goods and matching workers with jobs.

2.1. Basic structure

We describe below a one-sector equilibrium lifecycle model with many countries, atomistically competitive product and capital markets, and bargaining and matching in labor markets. The model is a version of models previously suggested by Merz (1995) and den Haan et al. (1997) for economies without capital mobility and infinitely lived households. It also has common features with models sometimes used to illustrate the effects of international capital mobility on savings and investment, such as the one by Obstfeld (1986).[1]

Countries are indexed by $i = 1, \ldots, N$ and time is indexed by $t = 1, \ldots, \infty$. At every t each country is endowed with a generation of two-period lived households: L_i workers and N_i entrepreneurs. We normalize world labor supply to one, that is,

$$\sum_{i=1}^{N} L_i = 1. \tag{2.1}$$

Households of each generation $t = 1, \ldots$ have a common utility function

$$u(c_t^t, c_{t+1}^t) = \log c_t^t + (1+\rho)^{-1} \log c_{t+1}^t \qquad \rho > -1 \tag{2.2}$$

expressed over their lifecycle consumption vector (c_t^t, c_{t+1}^t), and a lifecycle leisure endowment vector $(1, 0)$ for workers and $(0, 0)$ for entrepreneurs. In this framework, households receive labor income in the first period of life - a wage rate w_t if employed and unemployment compensation bw_t if unemployed - and save a fraction $s = 1/(2+\rho)$ in the form of claims to capital for next-period consumption. In the next period they sell their capital stock to entrepreneurs at the rental r_{t+1}

[1] Obstfeld's (1986) objective was to show that perfect international capital mobility is consistent with the kind of correlations between investment and savings reported by Feldstein and Horioka (1980). His mecahnism is also present in our model: a positive TFP shock increases domestic savings and attracts capital from abroad, further increasing domestic investment.

and consume the income $sw_t r_{t+1}$ or $sbw_t r_{t+1}$. Capital depreciates completely in production.[2]

A single perishable consumption good is produced in each country from capital and labor via a stochastic constant returns technology

$$y_t^i = \theta_t^i f(k_t^i) \tag{2.3}$$

which relates output per worker, y_t^i, with capital per worker, k_t^i, and a stochastic total factor productivity term, θ_t^i. The function $f : \Re_+ \to \Re$ is a well-behaved production function with standard properties, and the vector $\theta_t = (\theta_t^1, \ldots, \theta_t^N)$ of TFP shocks has a well defined joint distribution conditional on the realization of its lagged value θ_{t-1}.

Entrepreneurs create new jobs at a unit cost $\kappa > 0$ which measures the resources absorbed in setting up the job and hiring a worker. It is a constant for all periods and countries. A fraction of the jobs are matched to workers and the remaining fraction remains idle. All jobs are destroyed at the end of the period and a new job creation round begins next period. The entrepreneurs' income is 0 for each idle job and the profit rate is π_t for each occupied job. We show below that competitive capital markets and free job entry ensure that on average entrepreneurs make zero net income.

Jobs are matched with available workers by a constant-returns-to scale search technology. The intensive form of that technology is a function $m : [0, \infty] \to [0, 1]$ which connects the fraction m_t of labor force matches with the ratio n_t of jobs to total labor supply. Formally

$$m_t^i = m(n_t^i). \tag{2.4}$$

This is an increasing, concave function with the following properties:

$$\lim_{n \to 0}[m(n)/n] = 1 \qquad \lim_{n \to \infty}[m(n)] = 1 \tag{2.5}$$

Examples of such a function are $m(n) = \left\{ n/(1 + n^{\gamma})^{1/\gamma}, \gamma > 0; 1 - \exp(-\gamma n), \gamma > 0 \right\}$.

We have now at hand the tools we need to describe how factor markets operate. In each period t, once the state of nature θ_t is known, entrepreneurs create Ln_t

[2] Blanchard (1985) shows that equilibria in overlapping generations economies with identically homothetic preferences and potentially infinite lifecycles are qualitatively similar to those of economies with two-period lifecycles.

jobs which are matched with the L young workers to produce Lm_t occupied jobs. A wage bargain takes place which determines the wage rate w_t and profit rate π_t. Entrepreneurs then buy capital stock k_t for each occupied job at the rental r_t, which either exhausts domestic savings or is equal to a world rental rate. Production occurs next, and at the end of the period wage payments and consumption take place.

2.2. Domestic labor markets

Once a match occurs in period t between a worker and a new job, the wage rate w_t paid by the firm is set as the outcome of a Nash bargaining procedure between the entrepreneur and each worker. Formally

$$w_t = \arg\max \left\{ (V_t - V_0)^{\beta} (\Pi_t - \Pi_0)^{1-\beta} \right\}. \qquad (2.6)$$

Here (V_t, Π_t) are payoffs to the worker and firm in a successful match, (V_0, Π_0) are the corresponding payoffs for an unsuccessful match, and $\beta \in [0, 1]$ is the worker's bargaining power. Payoffs are conditional on the current TFP shock,[3] and are expressed as current income equivalents of lifetime utility for each party. Following Rubinstein (1982) and Binmore, Rubinstein and Wolinski (1986), we interpret the worker's bargaining weight β as a proxy for the combined rates of time preference, ρ_w and ρ_e, of a worker and an entrepreneur engaged in a bargaining game with alternating offers. As the time interval between counteroffers shrinks to zero, the unique subgame perfect equilibrium of this game is the Nash bargaining solution from equation (2.6) with weight $\beta = \rho_e/(\rho_e + \rho_w)$. In this game "bargaining power" is synonymous with "patience".

Suppose wages are taxed at the rate $\tau_t \in [0, 1]$ and unemployed workers receive unemployment compensation $bw_t(1 - \tau_t)$, proportional to the net economy-wide wage rate, financed by wage taxes. If π_t is each firm's variable profit from a match and $(1 - \tau_t)w_t$ is each worker's after-tax income, payoffs turn out to be proportional to income for any homothetic utility function. In particular, the indirect utility function that corresponds to a two-period homothetic utility is

[3] Another possibility, which we do not analyze here, is to bargain over expected payoffs before the state of nature is realized. This bargain, which spreads TFP risks over the entire population, may be of particular interest to workers who are unable to trade contingent claims in domestic or international markets.

the product of a function that is increasing in lifecycle income and another that depends only on prices. Formally,

$$
\begin{aligned}
V_t &= (1-\tau_t)w_t Z_t \qquad (2.7)\\
V_0 &= b w_t Z_t (1-\tau_t)\\
\Pi_t &= \pi_t Z_t\\
\Pi_0 &= 0
\end{aligned}
$$

The proportionality constant Z_t will not affect the outcome of the bargain; its precise form depends on the utility function and the one-period ahead interest rate.

In view of equation (2.7), the bargaining problem becomes

$$w_t = \arg\max \left\{ [(1-\tau_t)w_t - b w_t (1-\tau_t)]^{\beta} \pi_t^{1-\beta} \right\} \qquad (2.8)$$

Solving this, one obtains for the symmetric Nash equilibrium,

$$w_t - b w_t = \beta (w_t - b w_t + \pi_t). \qquad (2.9)$$

Firms take as given the outcome of this bargain and the rental rate, r_t, of capital. We assume later that capital depreciates completely after one period, so r_t would be one plus the rate of interest. Profit maximization then implies that the capital-labor ratio k_t satisfies

$$r_t = \theta_t f'(k_t) \qquad (2.10)$$

Therefore, variable profit per job is

$$\pi_t = \theta_t f(k_t) - r_t k_t - w_t = \theta_t w(k_t) - w_t \qquad (2.11)$$

where

$$w(k) \equiv f(k) - k f'(k) \qquad (2.12)$$

is the classical wage function, that is, the wage rate paid by a firm in an atomistically competitive labor market without productivity shocks.

Combining equations (2.9) and (2.11) we derive the terms of the wage bargain. The pre-tax wage rate is

$$w_t = \beta \theta_t w(k_t) \qquad (2.13)$$

and the firm's variable profit is

$$\pi_t = (1 - \beta)\theta_t w(k_t) \tag{2.14}$$

where β is defined by the generalized share of labor in the wage bargain

$$\beta \equiv \frac{\beta'}{1 - (1 - \beta')b}. \tag{2.15}$$

Job creation continues until profits from successful matches cover the costs of attracting new workers, that is, until

$$m_t \pi_t - \gamma n_t = 0. \tag{2.16}$$

Equation (2.16), the free-entry condition, and (2.14) describe how job creation depends on capital intensity and unemployment insurance. Specifically

$$\frac{n_t}{m_t}\gamma = (1 - \beta)\theta_t w(k_t) \tag{2.17}$$

From this expression and the properties of the matching technology laid out in equation (2.5), it is easy to show the following lemma:

Lemma 2.1. If the classical wage function $w(k)$ is concave in k, then for each $(\theta; \beta'; b)$ there exists a concave function $M(\theta; k; b)$, increasing in k and θ and decreasing in b, such that $m_t = M(\theta_t; k_t; b)$ solves equation (2.17). Furthermore $M(\theta; 0; b) = 0$, and $M(\theta; k; b) \to \infty$ as $k \to \infty$ for each fixed $b; \theta > 0$.

In other words, for any state of technology θ_t; employment increases with capital accumulation and decreases when unemployment benefits become more generous. Equation (2.17) is a key equation for our model as it links the capital stock with employment. International capital mobility influences employment through its influence on the capital intensity variable k_t in (2.17).

2.3. International capital markets

Asset markets direct household savings to firms. In economies without public debt or currency, aggregate household wealth equals the value of the capital stock. To see how this equality applies in our model, we recall that s, the savings rate out of wage income, is independent of the interest rate:

$$s = 1/(2 + \rho). \tag{2.18}$$

We suppose in what follows that unemployment compensation is financed by wage taxes in each t. Then, transfers do not influence aggregate household wealth and so, at time t, aggregate household wealth in country i is

$$W_t^i = sL_i m_t^i w_t \tag{2.19}$$

while capital stock at $t + 1$ is

$$K_{t+1}^i = L_i m_{t+1}^i k_{t+1}^i. \tag{2.20}$$

Equating world capital with world wealth implies

$$\sum_{i=1}^{N} L_i[m_{t+1}^i k_{t+1}^i - s\beta\theta_t^i w(k_t^i) m_t^i] = 0 \tag{2.21}$$

for all t. Perfect capital mobility requires

$$\theta_t^i f'(k_t^i) = \theta_t^j f'(k_t^j) \tag{2.22}$$

for all (i, j, t). Finally, labor market equilibrium connects employment with the capital stock as described in Lemma 2.1:

$$m_t^i = M(\theta_t^i, k_t^i; b) \equiv \mu(\theta_t^i, k_t^i) \qquad \text{all } (i, t) \tag{2.23}$$

Equilibrium with international capital mobility satisfies equations (2.21), (2.22) and (2.23) simultaneously. Without capital mobility, equation (2.22) does not apply, and equilibrium in each country satisfies instead the following equations:

$$m_{t+1}^i k_{t+1}^i = s\beta\theta_t^i w(k_t^i) m_t^i \tag{2.24}$$

$$m_t^i = \mu(\theta_t^i, k_t^i) \tag{2.25}$$

Equation (2.21) is of course still satisfied because each and every term in the summation is equal to zero by (2.24).

2.4. Equilibrium with immobile capital

The evolution of a closed economy is described in equations (2.24) and (2.25) where the state variable is the probability distribution of tomorrow's capital-labor ratio conditional on today's capital-labor ratio and on today's realized value of the

TFP shock. This formalization allows us to study independent as well as serially correlated disturbances. In general, we can derive this conditional distribution

$$H(k' \mid k; \theta) = \Pr\left\{ k^i_{t+1} = k' \mid k^i_t = k; \theta^i_t = \theta \right\} \tag{2.26}$$

from equation (2.24). Iterating forward, we obtain the $n-$period ahead conditional distribution

$$H_n(k' \mid k; \theta) = \Pr\left\{ k^i_{t+n} \leq k' \mid k^i_t = k; \theta^i_t = \theta \right\} \tag{2.27}$$

When the dynamical system (2.24) and (2.25) is well behaved, its asymptotic behavior follows an ergodic distribution

$$H^*(k') = \lim_{n \to \infty} H_n(k' \mid k_0; \theta_0) \tag{2.28}$$

which is independent of the initial conditions vector $(k_0; \theta_0)$.

2.5. Small economies with capital mobility

International capital mobility changes the dynamic behavior of unemployment because capital flows influence job creation and, in effect, redistribute jobs over national borders. The easiest way to study this influence is to assume that the number of countries is large (in the limit we should think of a continuum), and that TFP shocks θ^i_t are independent, identically distributed random variables with common mean $g \geq 1$. Then the law of large numbers permits us to replace the country-specific TFP shocks in equation (2.21) with their common expected value g, and the country-specific capital intensities k^i_t with the common value k_t they would have if $\theta^i_t = g; \forall(t; i)$.

The only thing that matters now is the evolution of this auxiliary variable k_t which is converted to the world capital rental, r^w_t, by the equation

$$g f'(k_t) = r^w_t. \tag{2.29}$$

From equations (2.21) and (2.22) we obtain

$$\theta^i_t f'(k^i_t) = g f'(k_t) \qquad \forall(i; t) \tag{2.30}$$

$$k_{t+1}\mu(g; k_{t+1}) = s\beta g \mu(g; k_t) w(k_t) \qquad \forall t \tag{2.31}$$

because $\sum_{i=1}^{n} L_i = 1$. This equation is deterministic and, if $w(k)$ is concave, its dynamic behavior is extremely simple: it has an unstable steady state at $k = 0$ and a stable one at $k = k^*(g)$. Figure 1 shows the implied evolution of the capital stock and the world rental rate.

We give below an example of how capital mobility influences unemployment.

2.6. Unemployment responses to temporary productivity shocks

Suppose that a small country i experiences at time $t = 0$ a one-period reduction in its total factor productivity below the expected value g while all other countries maintain constant TFP values. Suppose also that the world capital stock in (2.31) has converged to its state-state value $k^*(g)$: How will the unemployment rate $u_t^i = 1 - m_t^i = 1 - \mu(\theta_t^i; k_t^i)$ react to this productivity reduction? And what role does capital mobility play in the impulse response function of the unemployment rate?

Maintained assumptions are

$$\begin{aligned} \theta_t^i &= \theta_0 < g \qquad t = 0 \\ &= g \qquad\qquad t \geq 1 \end{aligned} \tag{2.32}$$

$$\theta_t^j = g \qquad \text{for all } t \text{ and all } j \neq i \tag{2.33}$$

In the absence of international capital mobility, capital intensity in country i satisfies equation (2.24), i.e.,

$$\mu(\theta_{t+1}^i; k_{t+1}^i) k_{t+1}^i = s\beta\theta_t^i \mu(\theta_t^i; k_t^i) w(k_t^i) \tag{2.34}$$

When there is capital mobility, capital intensity is determined by TFP and the stationary value of the world interest rate. This means, for all $(i; t)$;

$$\theta_t^i f'(k_t^i) = g f'[k^*(g)]: \tag{2.35}$$

If all nations are at a stationary equilibrium before $t = 0$, then the response in the unemployment rate of i with capital mobility will be a spike at $t = 0$, i.e.,

$$\begin{aligned} u_t^i(0) &= 1 - \mu(\theta_0; k_0^i) \qquad t = 0 \\ &= 1 - \mu(g; k^*(g)) \qquad t \geq 1 \end{aligned} \tag{2.36}$$

where

$$\theta_0 f'(k_0^i) = g f'(k^*(g)). \tag{2.37}$$

Without capital mobility, the capital stock in country i adjusts gradually with a lag of one period, according to equation (2.34), but the capital intensity and the unemployment rate adjust faster because of the impact effect of the fall in TFP. Specifically,

$$\begin{aligned} u_t^i(c) &= 1 - \phi(\theta_0; k_0) \qquad t = 0 \\ &= 1 - \phi(\hat{k}_t) \qquad t \geq 1 \end{aligned} \tag{2.38}$$

where $\phi(\theta_0; k_0)k_0 = \phi(g; k^*(g))k^*(g)$ and the sequence $(\hat{k}_t)$ solves

$$\phi(g; k_1)k_1 = s\beta\theta_0 \phi[g; k^*(g)]k^*(g) \tag{2.39}$$

$$\phi(g; k_{t+1})k_{t+1} = s\beta g \phi(g; k_t)w(k_t); \qquad t \geq 1. \tag{2.40}$$

In the absence of capital mobility the capital stock does not change in the period of the negative shock but job creation falls. Capital intensity per job rises temporarily, with the rise in unemployment, and this mitigates the rise in unemployment. In the next period the aggregate capital stock falls in response to the fall in savings in the previous period, reducing the demand for labor despite the recovery of TFP. Unemployment eventually converges to the stationary rate $u^* = 1 - \phi(g; k^*(g))$. The initial maximal response is bigger when there is international capital mobility, that is,

$$u_0^i(o) > u_1^i(c) > u_2^i(c) > \ldots > u^* \tag{2.41}$$

and under plausible conditions $u_0^i(o) > u_0^i(c)$ as well (see the next section). The reason is that the capital stock falls more when it is able to move abroad. Mathematically, this intuitive result comes about because, for any concave function, the arbitrage condition (2.37) makes k_0^i an increasing convex function of θ_0^i while, in the closed economy equilibrium of equation (2.39), k_1^i is an increasing concave function of θ_0^i. All we need for this result is that $\phi(\theta; k)$ be concave, that is, the classical wage function $w(k)$ should be an increasing concave one. This proves

Proposition 2.2. Suppose the utility function is Cobb-Douglas and the classical wage function $w(k)$ is concave. Then the impulse response of the domestic unemployment rate to a one-time total productivity shock has greater amplitude if capital is perfectly mobile than if it is completely immobile.[4]

The two impulse responses are shown in figure 2.

We now derive explicit dynamic equations for the capital stock and unemployment from Cobb-Douglas functional forms. This illustrates the general results so far derived and enables us to derive more results that can be tested against realistic parameter values and data.

3. A Cobb-Douglas example

Let the production function be $f(k) = k^{\alpha}$ and, after appropriate normalizations, the matching function be $m = n^{1-\eta}$ for all countries and periods. Parameters are chosen such that $n \leq 1$ always. Both α and η are constants taking values strictly between 0 and 1. In simulations of equilibrium matching models the parameters η and β' are usually set equal to 0.5. Recall that β' is the share of labor in the wage bargain. Its equality to the elasticity of the matching function implies that the search externalities due to the matching functions are internalized (see Hosios, 1990, Pissarides, 2000). Plausible values for the unemployment insurance parameter b raise the realized share of labor to about 0.6 (see the definition in (2.15)) but not higher. In the context of our model, m is the employment rate and n is the ratio of the number of jobs created each period to the labor force.

Under the Cobb-Douglas restrictions equations (2.12)-(2.14) imply that the incomes of workers and entrepreneurs are, respectively,

$$w_t = \beta\theta_t(1-\alpha)k_t^{\alpha} \tag{3.1}$$

$$\pi_t = (1-\beta)\theta_t(1-\alpha)k_t^{\alpha}. \tag{3.2}$$

The job creation condition (2.16), equates expected profit income from a job, $m_t\pi_t/n_t$, with the cost of creating a job, κ:

$$(1-\alpha)(1-\beta)\theta_t k_t^{\alpha} n_t^{-\eta} = \kappa. \tag{3.3}$$

[4] We note that if the shock that causes the initial change is not in TFP but in a household parameter, e.g. the savings rate s or unemployment parameter b, international capital mobility reduces the amplitude of fluctuations. For example, a fall in either s or b reduces the domestic capital stock for each θ_t, reducing the demand for labor. International capital mobility restores the capital stock to its pre-shock level with no effect on labor demand.

Combining the matching function $m_t = n_t^{1-\eta}$ with the job creation condition (3.3) we derive a log-linear relation between employment and the capital stock, corresponding to the $\mu(k)$ function of section 2:

$$m_t = \left(\frac{(1-\alpha)(1-\beta)}{\kappa}\theta_t k_t^{\alpha}\right)^{(1-\eta)/\eta}. \tag{3.4}$$

3.1. No international capital mobility

Saving in the absence of international mobility is a constant fraction of wage income, which with wage rate as in (3.1) and employment rate m_t, gives $sm_t\beta\theta_t(1-\alpha)k_t^{\alpha}$. As before, s is given by the constant in (2.18). Next period's capital stock, $m_{t+1}k_{t+1}$, is equal to this period's saving, giving the capital market clearing condition,

$$m_{t+1}k_{t+1} = sm_t\beta\theta_t(1-\alpha)k_t^{\alpha}. \tag{3.5}$$

Substitution of m_t from (3.4) into (3.5) gives the equation determining the dynamics of the capital-labor ratio in the absence of capital mobility

$$\begin{aligned}\ln k_{t+1} = {} & \frac{\eta}{\alpha(1-\eta)+\eta}\ln s\beta(1-\alpha) + \frac{\alpha}{\alpha(1-\eta)+\eta}\ln k_t \\ & - \frac{1-\eta}{\alpha(1-\eta)+\eta}\ln\theta_{t+1} + \frac{1}{\alpha(1-\eta)+\eta}\ln\theta_t.\end{aligned} \tag{3.6}$$

The capital-labor ratio in period $t+1$ depends negatively on the contemporaneous shock because a positive θ_{t+1} does not change the total capital stock but increases desired employment. So the existing capital stock is spread more thinly among a larger number of jobs. By contrast, capital accumulation increases one period after a shock has taken place, so if say, θ_t is positive, there is more capital in period $t+1$ and more capital per job as well.

The employment dynamics for the closed economy are derived by making use of (3.4) and (3.6). Substitution of k_t from (3.4) into (3.6) gives the difference equation

$$\ln m_{t+1} = \frac{\alpha(1-\eta)}{\alpha(1-\eta)+\eta}B + \frac{\alpha}{\alpha(1-\eta)+\eta}\ln m_t + \frac{1-\eta}{\alpha(1-\eta)+\eta}\ln\theta_{t+1} \tag{3.7}$$

$$B \equiv \ln s\beta(1-\alpha) + \frac{1-\alpha}{\alpha}\ln\frac{(1-\alpha)(1-\beta)}{\kappa}. \tag{3.8}$$

In contrast to the equation for the dynamics of the capital stock, employment in period $t+1$ depends only on the realization of the contemporaneous shock and on lagged shocks through a distributed lag on employment.

We consider some of the properties of this difference equation. First, suppose the value of the shock θ is 1 for a sufficiently long period of time for equation (3.7) to practically reach its steady state and in period t jumps to a higher positive value, say θ', which it keeps for ever. Employment is practically at its steady-state value of $\exp(B\alpha(1-\eta)/\eta(1-\alpha))$ up to $t-1$, and starts rising at t. In period t it rises for given aggregate capital stock, so the capital-labor ratio falls. Savings rise in period t so in period $t+1$ the capital stock begins to rise, providing another reason for the rise in employment. The biggest single rise in employment takes place in the period of the shock, t, and subsequent rises are in decreasing amounts. Eventually, employment converges to the new steady state, where it takes the value,

$$\ln m' = \frac{1-\eta}{\eta(1-\alpha)}(\alpha B + \ln\theta'). \tag{3.9}$$

Next, suppose that $\ln\theta_t$ follows an autoregressive process

$$\ln\theta_t = \rho\ln\theta_{t-1} + \varepsilon_t \tag{3.10}$$

with $0 \le \rho < 1$; $E(\varepsilon_t) = E(\varepsilon_t\varepsilon_s) = 0\ \forall t, s \neq t$; $E(\varepsilon_t^2) = \sigma^2$. Then the unconditional expected value of employment in this economy satisfies

$$E(\ln m) = \frac{\alpha(1-\eta)}{\eta(1-\alpha)}\ln s\beta(1-\alpha) + \frac{1-\eta}{\eta}\ln\frac{(1-\alpha)(1-\beta)}{\cdot}. \tag{3.11}$$

The Appendix shows that its variance is

$$\mathrm{var}(\ln m_t) = \frac{(1-\eta)^2}{\eta(1-\alpha)[\eta(1-\alpha)+2\alpha]}\frac{\eta(1-\alpha)+\alpha(1+\rho)}{\eta(1-\alpha)+\alpha(1-\rho)}\frac{\sigma^2}{1-\rho^2}. \tag{3.12}$$

Higher savings rate increase mean employment because they imply more capital and more job creation (see also Bean and Pissarides, 1993). A higher share of labor in the division of job surplus, represented by higher β, has two effects on mean employment that work in opposite direction. On the one hand, it implies more savings, which increases employment, but on the other hand it implies less expected profit and so less job creation. For a small increase in β the overall effect is

$$\frac{\partial E(\ln m)}{\partial\beta} = \frac{1-\eta}{\beta\eta}\left(\frac{\alpha}{1-\alpha} - \frac{\beta}{1-\beta}\right). \tag{3.13}$$

For plausible parameter values this expression is negative and sufficiently far from zero that even small variations in these coefficients would still imply that higher share of labor reduces employment. The share of labor in the wage bargain, β, is usually fixed at 1/2, or, with unemployment insurance at an even higher value. The share of capital, α, is never as high as 1/2, and usually it is closer to 1/3. So the model implies that higher UI benefits increase unemployment, as we would expect.

3.2. The small economy with international capital mobility

In the small economy with capital mobility the supply of capital is infinitely elastic. For a Cobb-Douglas production function the capital market equilibrium condition (3.5) is replaced by the equality of the marginal product of capital $\alpha\theta_t k_t^{-(1-\alpha)}$ to the constant world rental rate r^w. In logs,

$$\ln k_t = \frac{-\ln r^w + \ln \alpha}{1-\alpha} + \frac{1}{1-\alpha}\ln\theta_t. \tag{3.14}$$

Combining as before the relation between the capital stock and employment in (3.4) with the capital market equilibrium condition (3.14) we get the equation for the dynamics of employment in the small economy with international capital mobility:

$$\begin{aligned} \ln m_t &= \frac{1-\eta}{\eta(1-\alpha)}(\alpha C + \ln\theta_t) \\ C &\equiv \eta \ln\frac{\alpha}{r^w} + \frac{1-\alpha}{\alpha}\ln\frac{(1-\alpha)(1-\beta)}{\cdot}. \end{aligned} \tag{3.15}$$

The main feature that stands out of the employment equation for this economy is that it is free of internal dynamics. Adjustment is instantaneous, by our assumption that the capital stock is infinitely elastic and it will enter or leave the country in response to the productivity shocks. If θ changes from 1 to some positive value $\theta' > 1$ employment instantly rises by $(1-\eta)\ln\theta'/\eta(1-\alpha)$. This rise is the same as the maximum rise achieved in the economy without capital mobility, under similar circumstances but only if θ stays at the higher value for a long time. Again, the reason for this difference in the dynamics is that the economy without capital mobility needs to accumulate the capital before it can create the new jobs needed to increase employment whereas with capital mobility the economy imports it.

The comparison of the moments of employment under the autoregressive assumptions on θ made in (3.10) reveals some interesting patterns. In the economy with capital mobility the mean of the log of employment, when θ_t obeys (3.10), is $\alpha(1-\eta)C/\eta(1-\alpha)$. Comparison with (3.11) shows that the difference between the expected value of the log employment in the economy without capital mobility, now distinguished by superscript c; and the expected value of the log employment in the economy with capital mobility, denoted $E(\ln m^o)$; is

$$E(\ln m^c - \ln m^o) = -\frac{\alpha(1-\eta)}{\eta(1-\alpha)} \ln \frac{s\beta(1-\alpha)}{\alpha} r^w. \tag{3.16}$$

If the world consists of many countries like the one that we are discussing, which receive independent shocks, the marginal product of capital in each is equal to a constant. Capital mobility removes all uncertainty on the rate of return to capital, and so the capital stock of the representative country is, on average, the one derived from (3.6) when $\ln \theta_t$ is set equal to 0 (its mean value) for all t. The result is

$$\ln k^o = \frac{1}{1-\alpha} \ln s\beta(1-\alpha) \tag{3.17}$$

and combining this with (3.14) we get the value of the world rental rate

$$r^w = \frac{\alpha}{s\beta(1-\alpha)}. \tag{3.18}$$

Substituion from (3.18) into (3.16) then gives the following result for the unconditional employment means:

$$E \ln m^c = E \ln m^o. \tag{3.19}$$

Over long periods of time, and in a world of many small economies and free capital mobility, the mean of the log of employment will be the same as the mean of the log in the economy without the capital mobility.

Equation (3.19) says that for plausible parameter values, in the long run, capital mobility has little or no influence on the expected value of the unemployment rate, $u = 1 - m$. Applying Newton's formula to $\ln m$ and dropping terms of order higher than two, we obtain

$$\ln m = -u - \frac{1}{2}u^2. \tag{3.20}$$

Taking expected values yields

$$E\ln m = -Eu - \frac{1}{2}Eu^2 \qquad (3.21)$$

which is very close to the value of asymptotic unemployment when realizations of u are small relative to 1.

We can easily obtain a result similar to the one in (3.19) for the capital-labor ratio with and without capital mobility, by taking unconditional expected means of (3.14) and (3.6) respectively. The value of output is $m_t\theta_t k_t^{\alpha}$ and so it follows that a similar result also holds for output.

The key difference between economies with and without capital mobility is the variance of the asymptotic unemployment rate. In the open economy adjustment to any shock is faster (instantaneous under our extreme assumptions) so variance will be greater. From (3.15) we see that the variance of employment in the open economy satisfies

$$\mathrm{var}(\ln m^o) = \frac{(1-\eta)^2}{\eta^2(1-\alpha)^2}\frac{\sigma^2}{1-\rho^2}. \qquad (3.22)$$

Comparison with the variance of the log in the closed economy, (3.12) and now denoted $\mathrm{var}(\ln m^c)$, unambiguously gives

$$\mathrm{var}(\ln m^o) > \mathrm{var}(\ln m^c) \qquad (3.23)$$

for all values of ρ strictly less than 1.

Using Newton's formula again yields

$$\begin{aligned}[\ln m - E\ln m]^2 &= \left[-u - \frac{1}{2}u^2 + Eu + \frac{1}{2}Eu^2\right]^2 \\ &= u^2 + (Eu)^2 - 2uEu + \text{higher order terms} \qquad (3.24)\end{aligned}$$

with $u = 1 - m$ being the unemployment rate. Taking expected values on both sides of (3.24), we obtain

$$\mathrm{var}(\ln m) = Eu^2 - (Eu)^2 = \mathrm{var}(u). \qquad (3.25)$$

In other words, capital mobility raises the variability of the unemployment rate. We can rewrite (3.23) as follows

$$\mathrm{var}(u^o) > \mathrm{var}(u^c). \qquad (3.26)$$

By making use of (3.14) and (3.6) we can easily show that the valiance of capital intensities is higher when there is international capital mobility (intuitively, the higher variance in employment is due to the higher variance in the capital stock). Therefore output $m_t\theta_t k_t^{\alpha}$ also has more log-variance for a given distribution of θ when there is international capital mobility. Since the log is a convex function it follows that the mean value of output with capital mobility is higher than the mean of value of output in the absence of capital mobility. To a first approximation, given plausible realizations of the employment rate (say in the range 0.9-1.0), the higher mean output is due to higher mean capital stock over long periods of time.

3.3. The large economy with capital mobility

Before looking at numerical examples, we consider the implications of capital mobility for a large economy by studying equilibrium in a two-country world, with the two countries are assumed to be of equal size to facilitate computations. Country variables are distinguished by superscript 1 or 2, as appropriate. Each country is hit by a shock θ_t in each period t: The shocks have common variance and non-zero covariance.

In the absence of capital mobility between the two countries, equilibrium satisfies the same properties as before, with capital accumulation given by (3.6) and employment dynamics by (3.7). But equilibrium with capital mobility is now different, because the absence of many small countries does not allow us to apply the law of large numbers to set the rate of return to capital equal to a constant. As before, however, the rate of return to capital in the two countries is equalized. To find the equilibrium we aggregate to get world savings in period t:

$$s\beta(1-\alpha)\left(m_t^1\theta_t^1 k_t^{1\alpha} + m_t^2\theta_t^2 k_t^{2\alpha}\right): \tag{3.27}$$

World capital stock in period $t+1$ is

$$m_{t+1}^1 k_{t+1}^1 + m_{t+1}^2 k_{t+1}^2 \tag{3.28}$$

and the difference equation governing the evolution of capital is

$$m_{t+1}^1 k_{t+1}^1 + m_{t+1}^2 k_{t+1}^2 = s\beta(1-\alpha)\left(m_t^1\theta_t^1 \left(k_t^1\right)^{\alpha} + m_t^2\theta_t^2 \left(k_t^2\right)^{\alpha}\right): \tag{3.29}$$

Each country still satisfies the job creation condition (3.4) which, when substituted into (3.29), gives a single difference equation in the two capital stocks. In order to solve this equation we need a condition for the distribution of world capital between the two countries. But this is provided by the condition that the rate of return to capital in each country should be equalized. Since the rate of return to capital in each country given by $\alpha\theta_t^i(k_t^i)^{-(1-\alpha)}$; this implies that the world distribution of capital satisfies

$$\frac{k_t^1}{k_t^2} = \left(\frac{\theta_t^2}{\theta_t^1}\right)^{-\frac{1}{1-\alpha}} \qquad \forall t. \tag{3.30}$$

The four equations (3.29), (3.30) and (3.4) for each country reduce to two equations in the capital stocks and employment levels. It turns out that the four difference equations are similar to the ones for the closed economy, except for the "shock" terms. We write here the equation for employment in country 1; the others following immediately:

$$\begin{aligned} \ln m_{t+1}^1 = {} & \frac{\alpha(1-\eta)}{\alpha(1-\eta)+\eta}B + \frac{\alpha}{\alpha(1-\eta)+\eta}\ln m_t^1 \\ & + \frac{1-\eta}{\alpha(1-\eta)+\eta}\left(\ln\theta_{t+1}^1 + \alpha\ln\frac{1+R_t^{1/\eta(1-\alpha)}}{1+R_{t+1}^{1/\eta(1-\alpha)}}\right) \end{aligned} \tag{3.31}$$

where $R_t \equiv \theta_t^2/\theta_t^1$: Comparing this equation with (3.7) shows that all terms are the same as in the economy without capital mobility, except that now there is a spillover from the other country, which depends on the ratio of the two shocks. The spillover is transmitted via capital movements.

The two-country case illustrates a richer model of world equilibrium. Both the saving rate and the relative return to capital influence employment, the former through the availability of world-wide capital and the latter through the international mobility of capital. In the absence of capital mobility, the key influence on employment is the availability of capital through savings; in the small economy with capital mobility it is the relative rate of return, since the supply of world capital is by definition large vis-a-vis the small country. The influence of the two productivity shocks on capital and employment in the large economy reflects the joint impact of capital availability and capital mobility. From (3.31) it immediately follows that the contemporaneous productivity shock in the domestic economy (θ^1_{t+1}) increases capital and employment through the importation of capital from the other country and the contemporaneous shock in the other country (θ^2_{t+1}) decreases it, though the export of capital. Last period's shocks (θ^1_t and θ^2_t) should both increase capital this period through the higher savings that they imply. But the own-country shock θ^1_t has an ambiguous effect in our equation because the domestic capital stock k^1_t already accounts for some of the influence of last period's shocks. For example, imagine a temporarily high θ^1_t relative to θ^2_t. This implies that capital is imported from country 2 in period t and that there is more saving in country 1. In period $t+1$ the higher savings will increase the capital stock k^1_{t+1} but the capital that was imported in period t will now be re-exported. This will act to reduce the domestic capital stock in period $t+1$ relative to period t; i.e. the positive effect of k^1_t on k^1_{t+1} is counteracted by a negative influence from the subsequent fall in domestic TFP.

The Appendix shows that when the two productivity shocks are AR1 with common autocorrelation ρ and cross-correlation coefficient r, the variance of each country's shock with perfect capital mobility is given (to a first-order approximation) by

$$\left(1+\frac{\alpha[\alpha+\eta(1-\alpha)]}{\eta^2(1-\alpha)^2}(1-\rho)(1-r)\right)\frac{\sigma^2}{1-\rho^2}. \tag{3.32}$$

The mean of the shock is 0 in both economies. In the absence of international capital mobility the mean is also zero but the variance is $\sigma^2/(1-\rho^2)$. Therefore the ratio of variances is

$$1+\frac{\alpha[\alpha+\eta(1-\alpha)]}{\eta^2(1-\alpha)^2}(1-\rho)(1-r)\geq 1, \tag{3.33}$$

with equality holding only in the case where the two shocks are perfectly (positively) correlated. In this case the rates of return to each country are always equal without capital mobility, so each country operates as if capital were not mobile. In the absence of a perfect correlation in the shocks, the variance of employment with capital mobility is always higher than the variance without capital mobility. The difference is greater the less covariance there is between the shocks in each country: with less correlation, rates of return to capital in the absence of capital mobility are less correlated as well, so more capital flows between the countries. The maximum variance is achieved when the shocks are perfectly negatively correlated. In this case when a country gets a positive shock the other gets a negative one, maximizing the di¤erence in the rates of return to capital.

4. A numerical example and some evidence

Our motivation for studying international capital mobility is the recent increase in international capital movements in the OECD and the rise in unemployment rates observed in many European countries. We have shown that our model does not imply that the mean value of unemployment should increase with international capital mobility but that the variance of cyclical unemployment should. We present here some evidence to illustrate the extent of the penetration of domestic economies by international capital ‡ows and to look at the properties of cyclical unemployment. We also construct some numerical examples to illustrate the potential quantitative signi…cance of the mechanisms that we have identi…ed in the preceding sections of this paper.

Table 1 gives sample means for a measure of the penetration of foreign capital in OECD economies. The measure used is the in‡ow of foreign capital (net of outward movements of foreign capital) as a fraction of total domestic investment.[5] The striking feature of the data is the big increase in international capital mobility after the mid 1980s. There is no convincing explanation in the literature yet for this large increase, which is about four times as large as the increase in trade ‡ows. The increase is world-wide, although it is bigger in European countries (except Germany), following the single market process that started in 1986 and culminated in 1992 and 1999 (see de Menil, 1999). The rise is much bigger in small economies than in the G7.

Table 2 gives the standard deviations in the cyclical component of unemployment for two sub-samples, one before 1985 and one after. On average the standard deviation of unemployment is higher in the more recent sub-sample, as the model would predict. The rise is much bigger in small economies than in the G7. The unweighted average standard deviation in the G7 is the same in the two sub-periods

[5] This measure is likely to understate what we are trying to measure but we use it becasue it is readily available on a comparable basis and we need it only to illustrate recent developments. FDI measures only foreign investment when the control of the investment remains in the hands of the foreign investor. Our model includes investment made by foreigners and under the control of domestic producers, as, for example, when a foreign resident buys shares in a new issue.

but for the small economies it is larger by a substantial factor.

The question naturally arises whether the rise in the standard deviations of unemployment from the first to the second sample has anything to do with the rise in international capital flows. It is beyond the scope of this paper to undertake a full empirical test of this proposition, however, which would require a more complete model of unemployment. But we illustrate the potential importance of international capital mobility for the dynamics of unemployment by studying the properties of a calibrated model.

Suppose the production and matching technologies are Cobb-Douglas functions with intensive forms $f(k) = k^{1/3}; m(n) = n^{1/2}$. The ratio of the variance of unemployment with and without capital mobility implied by (3.12), (3.22) and (3.25) is

$$\frac{var(u^o)}{var(u^c)} = \left(1 + \frac{2\alpha}{\eta(1-\alpha)}\right)\left(\frac{\eta(1-\alpha)+\alpha(1-\rho)}{\eta(1-\alpha)+\alpha(1+\rho)}\right); \tag{4.1}$$

so choosing the value $(1/3; 1/2)$ for the parameter vector $(\alpha; \eta)$ yields

$$\frac{var(u^o)}{var(u^c)} = 3\left(\frac{2-\rho}{2+\rho}\right). \tag{4.2}$$

The parameter ρ measures the persistence in the productivity shock. If we approximate it by the AR1 coefficient on a Solow residual, it is usually high, exceeding 0.9, in quarterly data. But our period of analysis is longer. It is the time that it takes for savings to transform into capital and into new jobs. The ratio of variances depends crucially on this parameter. For $\rho = 0$; the variance in the economy with capital mobility is three times as large as in the closed economy. For $\rho = 0.9$ it is only 1.7 times as large. For a middle value of 0.4 the variance when there is capital mobility is twice as large.

If we approximate the lognormal asymptotic probability distribution of employment with a symmetric, one-parameter distribution on some bounded interval, then capital mobility amplifies deviations of the unemployment rate from its expected value $\bar{u}$ by a factor equal to the square root of the ratio of the variances, that is, we can write

$$u^o - \bar{u} = \sqrt{\frac{var(u^o)}{var(u^c)}}(u^c - \bar{u}). \tag{4.3}$$

For example, in the case of $\rho = 0.4$; if in the trough of a symmetric business cycle the unemployment rate in the economy without capital mobility is 3 percentage points above the average unemployment rate, in the economy with capital mobility it will be about 4.2 percentage points above the average rate.

For the large economy the parameter vector $(\alpha, \eta) = (1/3, 1/2)$ gives the ratio of variances $1 + 2(1 - \rho)(1 - r)$. For independent shocks $r = 0$, this yields a value very close to the ratio of variances in the case of a small economy. For $\rho = 0$ the ratio is the same, 3, and for $\rho = 0.4$ it is 2.2. But if, in addition, we have $r = 0.5$, which is reasonable given the degree of synchronization of business cycles in modern open economies, the ratio of variances when $\rho = 0.4$ drops to 1.4. So the greater variability associated with international capital mobility is likely to be more a feature of small open economies than of large ones.

Now applying the parameter vector $(1/3, 1/2)$ to economy without capital mobility in (3.7) we get

$$\ln m_t = 0.25B + 0.5 \ln m_{t-1} + 0.75 \ln \theta_t. \tag{4.4}$$

although our main interest is in the standard deviations of unemployment, which are unaffected by the value of B, we can guess a reasonable value for B by taking the sample means of (4.4) to obtain

$$B \approx -2\bar{u}. \tag{4.5}$$

Substituing back into (4.4) we obtain

$$\ln m_t = 0.5(-\bar{u} + \ln m_{t-1}) + 0.75 \ln \theta_t. \tag{4.6}$$

In contrast, the dynamic equation for employment in the economy with capital mobility, (3.15) implies, given (3.18) which makes C identical to B,

$$\ln m_t = \bar{u} - 1.5 \ln \theta_t. \tag{4.7}$$

We calibrate (4.6) and (4.7) with annual data from several OECD countries for the period 1970-98. The shock $\ln \theta$ is the cyclical component of labor productivity (ratio of output to employment) derived by applying the Hodrick-Prescott filter to the series. The series obtained is very close to the Solow residual of real business cycle theory. We convert the calibrated series for $\ln m_t$ to unemployment by taking the exponential. Table 2 presents the results of the calibrations. In the majority of cases the ratio of the standard errors for unemployment with and without capital mobility is in the range implied for very small autocorrelations in the shocks in our numerical examples.

Comparing the standard deviations of actual and calibrated unemployment in Table 2 shows that, on average, actual standard deviations are smaller than calibrated ones. This provides an interesting contrast with real business cycle models, which usually under-predict the variance of employment (this is especially true of models with classical labor demand and supply functions but also of in…nite horizon search models, as in Merz, 1985). But for the small economies (i.e. excluding the G7) the rise in the standard deviations before and after the mid 1980s is approximately of the same order of magnitude as the rise predicted by our model when capital is allowed to move between countries. Although we cannot at this stage test whether the observed rise in the standard deviations is due to the higher international capital mobility, this result is supportive of further empirical research in this direction.

5. Conclusions

We have shown that international capital mobility can substantially amplify ‡uctuations in unemployment and output. Calibrations show that the variance of unemployment with perfect international capital mobility can be up to three times as large as the variance of unemployment without capital mobility, implying that cyclical peaks and troughs in unemployment overshoot those in economies without capital mobility by up to 1.7 percentage points. Small OECD economies have experienced a rise in the variance of their unemployment rates of this order of magnitude sometime in the mid 1980s, which coincided with a fast rise in international capital mobility. Such e¤ects imply that small economies trading in a world with large international capital ‡ows need to devise ways to insure the income of workers whose wealth is poorly diversi…ed across countries, because international capital ‡ows tend to shift income risk from capital to labor.

Future work in this area needs to address this policy question within reasonably estimated or calibrated models. Estimation should test whether the dynamic properties of unemployment are di¤erent when there is international capital mobility from those without. In particular, is adjustment to domestic shocks faster when the economy is small? Are foreign shocks transmitted to the domestic economy through capital flows when the economy is large? In the case of large economies, trade flows need also to be taken into account in empirical tests, because foreign shocks may influence trade prices and thereby be transmitted to the domestic economy. A higher foreign shock would then increase the domestic demand for labor, working against the effect of higher capital mobility. This trade channel should be less important in small economies as they are more likely to be faced with a perfectly elastic demand for their exports.

6. Appendix

6.1. The variance of employment in the closed economy

Let $\zeta \equiv \alpha/[\alpha(1-\eta)+\eta] < 1$. Then, the employment equation (3.7) becomes

$$\begin{aligned} \ln m_t &= \zeta(1-\eta)B + \zeta \ln m_{t-1} + \frac{\zeta(1-\eta)}{\alpha} \ln \theta_t \qquad (6.1) \\ B &\equiv \ln s^{\beta}(1-\alpha) + \frac{1-\alpha}{\alpha} \ln \frac{(1-\alpha)(1-\beta)}{.}. \end{aligned}$$

where

$$\ln \theta_t = \rho \ln \theta_{t-1} + \varepsilon_t \qquad (6.2)$$

with $0 \leq \rho < 1$; $E(\varepsilon_t) = E(\varepsilon_t \varepsilon_s) = 0 \ \forall t, s \neq t$; $E(\varepsilon_t^2) = \sigma^2$. We immediately find

$$E \ln m_t = \frac{\zeta(1-\eta)}{1-\zeta} B; \qquad E \ln \theta_t = 0; \qquad \mathrm{var}(\ln \theta_t) = \frac{\sigma^2}{1-\rho^2} \qquad \forall t. \qquad (6.3)$$

It also follows from (6.1) that

$$\begin{aligned} \mathrm{var}(\ln m_t - \zeta \ln m_{t-1}) &= \zeta^2(1-\eta)^2 \mathrm{var}(\alpha B + \ln \theta_t) \\ &= \frac{\zeta^2(1-\eta)^2}{\alpha^2} \frac{\sigma^2}{1-\rho^2}. \qquad (6.4) \end{aligned}$$

But

$$\begin{aligned} \mathrm{var}(\ln m_t - \zeta \ln m_{t-1}) &= \mathrm{var}(\ln m_t) + \zeta^2 \mathrm{var}(\ln m_{t-1}) - 2\zeta \mathrm{cov}(\ln m_t; \ln m_{t-1}) \\ &= (1+\zeta^2)\mathrm{var}(\ln m_t) - 2\zeta \mathrm{cov}(\ln m_t; \ln m_{t-1}). \qquad (6.5) \end{aligned}$$

To find the covariance note that

$$\begin{aligned}
\operatorname{cov}(\ln m_t, \ln m_{t-1}) &= E\left(\ln m_t - \frac{\zeta(1-\eta)}{1-\zeta}B\right)\left(\ln m_{t-1} - \frac{\zeta(1-\eta)}{1-\zeta}B\right) \\
&= E\left(\zeta \ln m_{t-1} + \frac{\zeta(1-\eta)}{\alpha}\ln \theta_t - \zeta\frac{\zeta(1-\eta)}{1-\zeta}B\right) \\
&\quad \left(\ln m_t - \frac{\zeta(1-\eta)}{1-\zeta}B\right) \\
&= \zeta E(\ln m_{t-1})^2 - 2\zeta\frac{\zeta(1-\eta)B}{1-\zeta}E\ln m_{t-1} + \zeta\left(\frac{\zeta(1-\eta)}{1-\zeta}B\right)^2 \\
&\quad + \frac{\zeta(1-\eta)}{\alpha}E(\ln\theta_t)(\ln m_{t-1}) \\
&= \zeta \operatorname{var}(\ln m_{t-1}) + \frac{\zeta(1-\eta)}{\alpha}E(\ln\theta_t)(\ln m_{t-1}). \qquad (6.6)
\end{aligned}$$

To find $E(\ln\theta_t)(\ln m_{t-1})$ we expand to get

$$\begin{aligned}
E(\ln\theta_t)(\ln m_{t-1}) &= E(\rho\ln\theta_{t-1} + \varepsilon_t)(\zeta(1-\eta)B + \zeta\ln m_{t-2} + \frac{\zeta(1-\eta)}{\alpha}\ln\theta_{t-1}) \\
&= \rho\zeta E(\ln\theta_{t-1})(\ln m_{t-2}) + \frac{\zeta(1-\eta)}{\alpha}E(\ln\theta_{t-1})^2, \qquad (6.7)
\end{aligned}$$

giving

$$E(\ln\theta_t)(\ln m_{t-1}) = \frac{\rho\zeta(1-\eta)}{\alpha(1-\rho\zeta)}\frac{\sigma^2}{1-\rho^2}. \qquad (6.8)$$

substitution from (6.8) into (6.6) and from (6.6) into (6.5) gives

$$\operatorname{var}(\ln m_{t+1} - \zeta\ln m_t) = (1-\zeta^2)\operatorname{var}(\ln m_t) - 2\frac{\zeta^2(1-\eta)^2}{\alpha^2}\frac{\rho\zeta}{1-\rho\zeta}\frac{\sigma^2}{1-\rho^2}. \qquad (6.9)$$

Therefore, making use of (6.4) we get

$$(1-\zeta^2)\operatorname{var}(\ln m_t) - 2\frac{\zeta^2(1-\eta)^2}{\alpha^2}\frac{\rho\zeta}{1-\rho\zeta}\frac{\sigma^2}{1-\rho^2} = \frac{\zeta^2(1-\eta)^2}{\alpha^2}\frac{\sigma^2}{1-\rho^2} \qquad (6.10)$$

and so

$$\operatorname{var}(\ln m_t) = \frac{1+\rho\zeta}{1-\rho\zeta}\frac{\zeta^2(1-\eta)^2}{\alpha^2(1-\zeta^2)}\frac{\sigma^2}{1-\rho^2}. \qquad (6.11)$$

Subtituting out the ζ we obtain the final result

$$\operatorname{var}(\ln m_t) = \frac{(1-\eta)^2}{\eta(1-\alpha)[\eta(1-\alpha)+2\alpha]}\frac{\eta(1-\alpha)+\alpha(1+\rho)}{\eta(1-\alpha)+\alpha(1-\rho)}\frac{\sigma^2}{1-\rho^2}. \qquad (6.12)$$

6.2. Properties of shocks, two large economies

The shock to country 1 employment is

$$\ln \phi^1_{t+1} = \ln \theta^1_{t+1} + \alpha \ln \frac{1 + R_t^{1/\eta(1-\alpha)}}{1 + R_{t+1}^{1/\eta(1-\alpha)}} \tag{6.13}$$

where $R_t = \theta^2_t / \theta^1_t$. In the absence of international capital mobility the shock is $\ln \theta^1_{t+1}$ and in country 2 shocks are symmetric to those of country 1: Let

$$\ln \theta^i_t = \rho \ln \theta^i_{t-1} + \varepsilon^i_t \qquad i = 1, 2 \tag{6.14}$$

and $0 \leq \rho < 1$; $E(\varepsilon^i_t) = 0$; $E(\varepsilon^i_t)^2 = \sigma^2$; $E(\varepsilon^1_t \varepsilon^2_t) = r\sigma^2$; $E(\varepsilon^i_t \varepsilon^j_{t-s}) = 0$ for $i, j = 1, 2$ and all $s \geq 1$ and $-1 \leq r \leq 1$ is the correlation coefficient between the two shocks. It follows that

$$E(\ln \theta^i_t) = 0 \qquad E(\ln \theta^i_t)^2 = \frac{\sigma^2}{1 - \rho^2}. \tag{6.15}$$

Expand now $\ln(1 + R^{1/\eta(1-\alpha)})$ around $R = 1$ as a function of $\ln R$:

$$\begin{aligned} \ln(1 + R^{1/\eta(1-\alpha)}) &= \ln 2 + \frac{\partial \ln(1 + R^{1/\eta(1-\alpha)})}{\partial \ln R} \ln R \\ &= \ln 2 + \frac{1}{2\eta(1-\alpha)} \ln R. \end{aligned} \tag{6.16}$$

Therefore,

$$\begin{aligned} \ln \left(\frac{1 + R_t^{1/\eta(1-\alpha)}}{1 + R_{t+1}^{1/\eta(1-\alpha)}} \right) &= \frac{1}{2\eta(1-\alpha)} (\ln R_t - \ln R_{t+1}) \\ &= \frac{1}{2\eta(1-\alpha)} \left[\ln \theta^2_t - \ln \theta^2_{t+1} - (\ln \theta^1_t - \ln \theta^1_{t+1}) \right]. \end{aligned} \tag{6.17}$$

Define now $\xi \equiv \alpha/\eta(1-\alpha)$. From (6.13) it follows that

$$\ln \phi^1_t = \left(1 + \frac{\xi}{2}\right) \ln \theta^1_{t+1} - \frac{\xi}{2} \ln \theta^1_t + \frac{\xi}{2} \left[\ln \theta^2_t - \ln \theta^2_{t+1} \right] \tag{6.18}$$

It follows that to the first approximation employed in (6.16) the means of the shocks in the two-country case are zero

$$E(\ln \phi^i_t) = 0 \qquad \forall t \text{ and } i = 1, 2. \tag{6.19}$$

The variance of the shock is

$$E(\ln \phi_t^1)^2 = E\left[\left(\left(1+\frac{\xi}{2}\right)\ln\theta^1_{t+1} - \frac{\xi}{2}\ln\theta^1_t\right)^2\right] + E\left[\left(\frac{\xi}{2}\left(\ln\theta^2_t - \ln\theta^2_{t+1}\right)\right)^2\right]$$
$$+2E\left[\left(\left(1+\frac{\xi}{2}\right)\ln\theta^1_{t+1} - \frac{\xi}{2}\ln\theta^1_t\right)\left(\frac{\xi}{2}\left(\ln\theta^2_t - \ln\theta^2_{t+1}\right)\right)\right] \quad (6.20)$$

Taking each term in turn and making use of (6.14) we get

$$E\left[\left(\left(1+\frac{\xi}{2}\right)\ln\theta^1_{t+1} - \frac{\xi}{2}\ln\theta^1_t\right)^2\right]$$
$$= \left(\left(1+\frac{\xi}{2}\right)^2 + \left(\frac{\xi}{2}\right)^2\right)\frac{\sigma^2}{1-\rho^2} - \left(1+\frac{\xi}{2}\right)\xi E\left(\ln\theta^1_t \ln\theta^1_{t+1}\right)$$
$$= \left(1+\xi(1-\rho)+\frac{\xi^2}{2}(1-\rho)\right)\frac{\sigma^2}{1-\rho^2} \quad (6.21)$$

$$E\left[\left(\frac{\xi}{2}\left(\ln\theta^2_t - \ln\theta^2_{t+1}\right)\right)^2\right] = (1-\rho)\frac{\xi^2}{2}\frac{\sigma^2}{1-\rho^2} \quad (6.22)$$

$$E\left[\left(\left(1+\frac{\xi}{2}\right)\ln\theta^1_{t+1} - \frac{\xi}{2}\ln\theta^1_t\right)\left(\frac{\xi}{2}\left(\ln\theta^2_t - \ln\theta^2_{t+1}\right)\right)\right]$$
$$= \frac{\xi}{2}\left(\left(\left(1+\frac{\xi}{2}\right)\rho - \frac{\xi}{2}(1-\rho)\right)E(\ln\theta^1_t\ln\theta^2_t) - \left(1+\frac{\xi}{2}\right)E(\ln\theta^1_{t+1}\ln\theta^2_{t+1})\right)$$
$$= -\frac{\xi}{2}(1+\xi)(1-\rho)r\frac{\sigma^2}{1-\rho^2}; \quad (6.23)$$

given that

$$E(\ln\theta^1_t\ln\theta^2_t) = \rho^2 E(\ln\theta^1_{t-1}\ln\theta^2_{t-1}) + r\sigma^2 = r\frac{\sigma^2}{1-\rho^2}.$$

Substituting each term from (6.21), (6.22) and (6.23) into (6.20) we get the variance

$$E(\ln\phi^1_t)^2 = (1+\xi(1+\xi)(1-\rho)(1-r))\frac{\sigma^2}{1-\rho^2}. \quad (6.24)$$

Substituting the value of ξ out we get

$$E(\ln\phi^1_t)^2 = \left(1+\frac{\alpha[\alpha+\eta(1-\alpha)]}{\eta^2(1-\alpha)^2}(1-\rho)(1-r)\right)\frac{\sigma^2}{1-\rho^2}. \quad (6.25)$$

7. Data sources and de…nitions

In‡ows of foreign capital. FDI in‡ows as a percentage of domestic investment. Source, IMF CD-ROM, International Financial Statistics.

Unemployment. OECD standardized unemployment series. Source, OECD CD-ROM Statistical Compendium.

Labor productivity. The ratio of GDP to employment. Source, OECD as above.

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Table 1
FDI inflow/domestic investment, %

Country	Sample means		
	1976-85	1986-91	1992-97
Australia	5.05	10.95	9.57
Austria	1.27	1.48	4.86
Belgium	7.09	16.41	26.11
Canada	5.35	5.34	6.59
Denmark	0.45	3.01	8.56
Finland	0.56	1.34	6.76
France	1.98	4.13	8.43
Germany	0.80	0.97	0.56
Greece	6.75	6.43	5.04
Iceland	2.33	0.00	2.37
Ireland	5.70	4.59	15.78
Italy	1.00	1.93	2.02
Japan	0.25	0.40	0.29
Netherlands	3.65	11.10	12.59
Norway	2.55	1.75	6.63
N. Zealand	7.98	19.22	21.83
Portugal	2.27	7.93	5.80
Spain	4.09	8.83	7.68
Sweden	0.96	4.89	20.94
Utd Kgdom	6.98	12.91	12.07
Utd States	0.48	1.52	1.48
Unweighted average	3.22	5.96	8.85
Small economies	3.62	7.00	11.04
Large (G7) economies	2.41	3.89	4.49

Table 2
Standard deviations of cyclical unemployment series

Country	Actual 1970-85	Actual 1986-98	Ratio	Simulated no cap mob	Simulated cap mob	Ratio
Australia	0.86	1.26	1.46	1.35	2.05	1.52
Austria	0.41	0.22	0.54	2.24	3.15	1.41
Belgium	0.98	1.27	1.30	0.74	1.48	2.00
Canada	1.10	1.17	1.06	1.19	1.76	1.40
Denmark	0.97	1.35	1.39	1.71	2.64	1.54
Finland	1.01	3.29	3.26	1.80	2.99	1.66
France	0.49	0.77	1.57	0.82	1.39	1.69
Germany	1.01	0.76	0.75	1.35	2.10	1.55
Ireland	1.40	1.33	0.95	1.39	2.33	1.68
Italy	0.33	0.58	1.76	1.27	2.16	1.70
Japan	0.15	0.30	2.00	1.55	2.46	1.59
Netherlands	1.32	0.93	0.70	2.19	3.45	1.57
Norway	0.48	0.87	1.81	1.39	2.29	1.65
N. Zealand	0.62	1.46	2.35	3.65	5.50	1.51
Spain	1.78	2.38	1.34	1.10	1.82	1.65
Sweden	0.42	1.39	3.31	1.28	1.87	1.46
Utd Kgdom	1.43	1.27	0.89	1.61	2.42	1.50
Utd States	1.08	0.74	0.68	0.80	1.33	1.66
Unweighted average	0.88	1.18	1.51	1.52	2.40	1.60
Small economies	0.93	1.43	1.67	1.71	2.69	1.60
Large (G7) economies	0.80	0.80	1.24	1.23	1.95	1.58

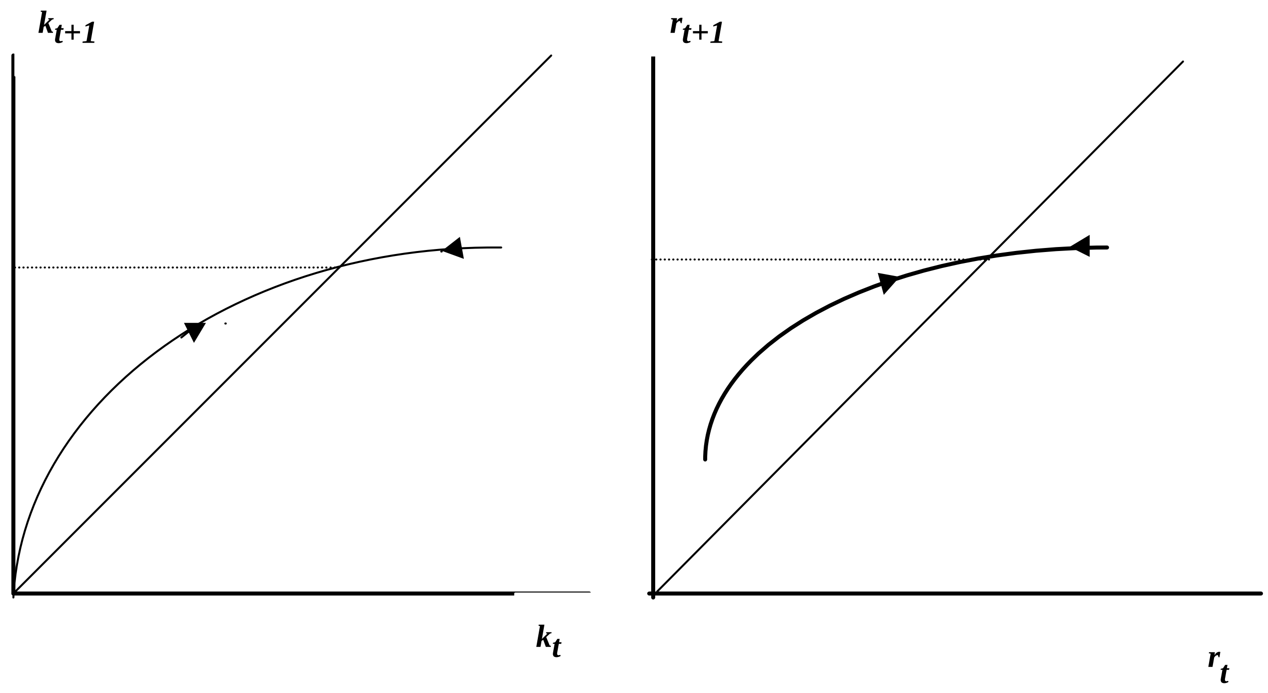

Figure 1

World capital stock and interest rate dynamics

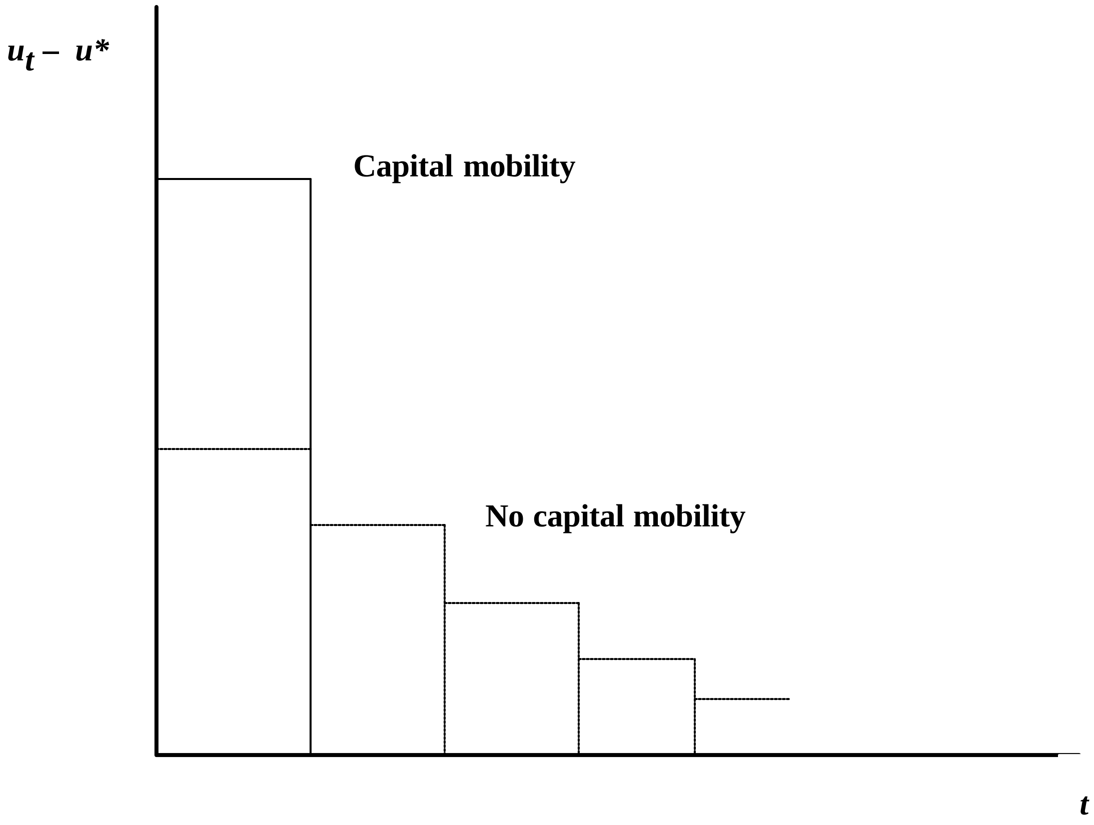

Figure 2

Capital mobility and unemployment responses to a one-off TFP shock