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WAGES, PROFITS AND CAPITAL FLIGHT

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Abstract: We model capital flight as the outcome of a non-cooperative differential game between workers (who control the wage share) and capitalists (who control investment at home and abroad). There are three equilibria for such a game. Along the interior equilibrium, the domestic economy becomes "decapitalized" as investors build up their holdings of foreign assets, in a situation reminiscent of the experience of several developing countries.

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I. Introduction

In recent years, many developing countries has suffered from low rates of domestic investment and capital flight.[1] Why don't capitalists invest in these capital-poor economies --where the marginal product of capital is presumably high-- preferring instead to transfer their resources abroad? A commonly heard explanation is that they fear monopoly unions in those countries will raise real wages after investment is in place, reducing the ex post return on such investments. Alternatively, populist political parties representing workers will tax the proceeds from investment, achieving the same result.[2]

Why should workers or their political allies act in such a way? Such behavior may be optimal in a static context, but is short-sighted in that it hinders investment and growth, which in turn would enlarge the feasible levels of consumption and real wages workers can obtain. A commonly heard retort is that if workers exercise wage restraint then the capitalists will either consume the surplus or take it abroad --and in neither one of these cases will greater domestic investment and growth reward the workers for their short-term sacrifice.

Hence, each group has at its disposal an instrument which can be used to reduce the income of the other group. Organized workers have the ability to redistribute income in their favor and at the expense of capitalists through wage-setting or tax policy. Capitalists, on the other hand, can take capital abroad and reduce worker income and consumption. If both groups act non-cooperatively and are unable commit to a future course of action, this situation can lead to underinvestment, slow growth and capital flight. There

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[1] See Cuddington (1986), World Bank (1988), Rodrik (1989).

[2] The story also requires that such parties control the congress and therefore fiscal policy, if the country is democratic.

are several countries whose experience seems to match this general description. A striking example is Argentina, a country whose dismal economic performance in the past half-century is often attributed to pervasive distributional conflicts.[3] A central feature of Argentina's troubles have been domestic underinvestment and massive capital flight.[4]

In this paper we present a model which replicates this developmental quandary. There are two groups, workers and capitalists, engaged in a dynamic game. Both groups are organized, in that all workers act together (e.g., through a union) and the same is true of capitalists. Workers control the share of wage income in total output, and capitalists control the allocation of the remainder. This remainder can be used by capitalists for their own consumption or for investment either at home or abroad. We assume that the fixed return on the foreign asset is below the constant marginal product of domestic capital, so that there is a cost associated with investing abroad.

Since the essence of the problem is that neither group can precommit, we compute the closed-loop Nash equilibria for this dynamic game between capitalists and workers. There can be three equilibria of this sort --two "extreme" solutions and an interior path. The interior equilibrium involves a shift in the portfolio of capitalists, away from domestic capital and toward foreign assets. The shift is gradual, even though the model is linear and there are no adjustment costs.

The model used resembles those in Lancaster (1973) and the

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[3] See O'Donnell (1978), Sourrouille and Mallon (1976). Of course, distributional conflicts were not limited to the capitalist-worker standoff. Conflicts among economic sectors (e.g. agriculture versus industry) and between the state and the private sector also played a role.

[4] Dornbusch and de Pablo (1987).

literature on resource extraction under common access (Levhari and Mirman, 1980; Kemp and Long, 1980; Reinganum and Stokey, 1985; Benhabib and Radner, 1988). Lancaster modeled the dynamic inefficiency that arises when monopoly unions and capitalists interact in a closed economy with a finite horizon. Our model extends his model to an open economy with an infinite horizon, and shows that capital flight may be a central manifestation of the dynamic inefficiency uncovered by Lancaster.

The paper is part of a growing literature that attempts to understand the political-economic determinants of growth, stabilization and development. The central message of this literature is that inefficient outcomes can be explained as non-cooperative equilibria of games among distributional groups. In a related paper, Alesina and Tabellini (1989) show that the presence of two parties that alternate in power, one representing capitalists and the other workers, can give rise to domestic underinvestment and capital flight. In the area of inflation and stabilization, Alesina and Drazen (1989) explain delayed stabilization as the result of a tug of war among groups which do not want to shoulder the burden of fiscal adjustment, while Aizenman (1989) shows that decentralized money creation by groups can lead to inefficiently high inflation rates.

II. The Model

Workers do not save, and consume their wage income every period. Hence, they have only one control variable (their own consumption) while capitalists have two --the amount they invest at home and the amount they consume.[5] Workers maximize

[5] The amount they invest abroad is then calculated as a residual.

$$U^w = \int_o^\infty \left(\frac{\sigma}{\sigma-1}\right)(w_t)^{\left(\frac{\sigma-1}{\sigma}\right)} e^{-\delta t}\, dt \tag{1}$$

where w is workers' total consumption (equal to the total wage bill), δ is the subjective rate of time preference and σ is the intertemporal elasticity of substitution in consumption. For realism and simplicity we restrict our analysis to the case where $0<\sigma<2$. Furthermore, we do not allow σ to be exactly equal to one.[6]

Workers understand that the excess of output over their total wage income can be either withdrawn or reinvested by capitalists. The budget constraint they therefore face is

$$\dot{k}_t = ak_t - w_t - z_t \equiv I_t \tag{2}$$

where z_t is the amount withdrawn by capitalists for their own consumption or for investment abroad and a is the constant marginal product of domestic capital.

The capitalists, on the other hand, maximize

$$U^k = \int_o^\infty \left(\frac{\sigma}{\sigma-1}\right)(c_t)^{\left(\frac{\sigma-1}{\sigma}\right)} e^{-\delta t} dt \tag{1'}$$

where c_t is capitalists' consumption. Notice that they have the same utility function and the same rate of time preference as

[6] The equilibria we describe below need not exist if σ is exactly equal to one. This is because, with logarithmic preferences, the amount consumed out of existing assets is independent of the rate of return obtained by a group. In any case, recent empirical research (Hall, 1988), suggests that σ may well be substantially below one.

workers. Capitalists can invest their savings either at home or abroad, and therefore face two budget constraints: equation (2) and

$$\dot{f}_t = rf_t + z_t - c_t \qquad (3)$$

where r is the fixed return on the foreign asset. A crucial assumption is that a>r, so that domestic capital is technologically superior to the foreign alternative. This assumption is meant to capture the inefficiency of capital flight away from capital-poor economies in which the domestic marginal product of capital is presumably higher than the world rate of interest.[7]

Finally, any feasible path must satisfy two further conditions. First, k_t and f_t must be continuous functions of time. That is, we rule out jumps in asset holdings caused by discrete stock shifts.[8] Second, an equilibrium must meet the usual non-negativity conditions. All these requirements can be summarized as

[7] Notice that in the absence of a monopoly union and/or capital levies, capitalists could enjoy higher profits by borrowing from the rest of the world at the rate r and investing the resources at home, where they would grow at the rate a. The same would be true of a cooperative solution between capitalists and the union. The absence of diminishing returns clearly makes the setting unrealistic, but also helps highlight the inefficiencies that arise from the non-cooperative game between capitalists and workers.

[8] For instance, there could be an upward jump in f_t and an equivalent downward jump in k_t if capitalists took a discrete "chunk" of domestic capital at time t and invested it abroad. However, at that point in time this would imply an infinite rate of disinvestment at home and an infinite rate of investment abroad. We rule out such a behavior by requiring that the rate of domestic disinvestment be bounded.

$$\underline{\theta} \leq \frac{\dot{k}_t}{k_t} \leq \bar{\theta}, \qquad k_t \geq 0 \qquad c_t > 0 \qquad w_t > 0 \qquad \forall t$$

$$k_{t=0} = k_o \qquad\qquad f_{t=0} = 0$$

We assume that the initial stock of foreign capital is zero in order to ease comparisons with the capital controls regime in which no foreign capital can ever be held. None of our results depend on this assumption.

Next we compute the subgame perfect equilibria to this game between capitalists and workers. We restrict our attention to "state-dependent" strategies, which specify the setting of the relevant control variable as a function of the current state(s) only.[9] We assume that in choosing its actions each group takes the rule employed by the other group as given. In other words, we compute a closed-loop Nash equilibrium.

We postulate simple linear policy rules. Workers employ

$$w_t = \beta k_t \tag{5a}$$

while capitalists choose

$$z_t = \alpha k_t \tag{5b}$$

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[9] That is, we neglect threats, triggers and other strategies based on the previous history of the game. For examples of simple state-dependent strategies and their associated equilibria, see Tabellini (1986) and Pohjola (1985). For more complex, history-dependent strategies, see Benhabib and Radner (1988).

where α and β are to be determined optimally.

The worker's Hamiltonian is

$$H^{w} = \frac{\sigma}{\sigma-1}(w_t)^{\frac{\sigma-1}{\sigma}} + \lambda[(a-\alpha)k_t - w_t] \tag{6a}$$

where λ is the costate variable associated with k. Workers maximize this Hamiltonian with respect to w_t. Of course, the workers' problem is coupled to the capitalists'. Their Hamiltonian is

$$H^{k} = \frac{\sigma}{\sigma-1}(c_t)^{\frac{\sigma-1}{\sigma}} + \mu_t I_t + \phi_t[rf_t + (a-\beta)k_t - I_t - c_t] + \overline{\omega}_t[\overline{\theta}k_t - I_t] + \underline{\omega}_t[I_t - \underline{\theta}k_t] \tag{6b}$$

where μ_t and ϕ_t are the costate variables associated with k_t and f_t respectively, and the ω's are the multipliers associated with the inequality constraints. Capitalists maximize (9) with respect to c_t and I_t.

There may be as many as three equilibria for this game, depending on whether the economy is along an interior or one of two corner solutions. We begin by describing the interior path.

The appendix shows that in that case the solution to this problem is

$$\beta = a - r \tag{7}$$

$$\alpha = \frac{r-\sigma(a-\delta)}{1-\sigma} \tag{8}$$

$$c_t = [r(1-\sigma)+\sigma\delta]\ [k_t+f_t] \tag{9}$$

Equations (7) and (8) show the optimal policy rules for workers and capitalists. The first expression can be understood by rewriting it as $r=a-\beta$, which has a ready interpretation. Since βk_t is the portion captured by workers out of the current capital stock, $a-\beta$ is the return from investing at home, viewed from the perspective of capitalists. This must be equal to r, the return from investing abroad. Given these relative returns, capitalists will withdraw αk_t from the capital stock per unit time, with α given by (8). Recall that workers consume all that they capture. Capitalists' consumption, on the other hand, is given by (9), which is the usual consumption function resulting from a dynamic optimization problem with this type of utility function.[10]

The appendix also shows that the trajectories of the state variables are

$$k_t = k_o e^{\frac{\sigma}{\sigma-1}[r+\delta-a]t} \tag{10}$$

$$f_t = [e^{\sigma(r-\delta)t} - e^{\frac{\sigma}{\sigma-1}(r+\delta-a)t}]k_o \tag{11}$$

Equations (7)-(11) completely characterize the equilibrium path of the system. Such a path satisfies the relevant transversality conditions.

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[10] We assume henceforth that $[r(1-\sigma)+\sigma\delta]>0$, so that consumption is positive everywhere.

When will capital flight occur along this path? To answer this and other questions, it is helpful to define the following condition

$$r(2-\sigma)+\delta\sigma-a > 0 \tag{12}$$

Since initial holdings of foreign capital are zero, we are interested in ascertaining whether they ever become positive. Inspection of equation (11) reveals that

__Proposition 1__: Capital flight ($f_t>0$ for $t>0$) will occur if condition (12) is satisfied and $\sigma<1$, or if condition (12) is not satisfied and $\sigma>1$.

The intuition for this result is as follows. Recall that capitalists remove capital at a rate $\alpha=[r-\sigma(a-\delta)]/(1-\sigma)$ per instant of time, and consume at a rate $[r(1-\sigma)+\sigma\delta]$. What is not consumed must be invested abroad --investing those resources at home would be equivalent to not appropriating them at all. Thus, there will be capital outflows if $[r-\sigma(a-\delta)]/(1-\sigma)>[r(1-\sigma)+\sigma\delta]$. Simple manipulation reveals that this is the same condition as (12) if $\sigma<1$, and viceversa if $\sigma>1$.

Notice that for this parameter constellations the capital outflow will be gradual, even though the model is linear and there are no adjustment costs. Over time, holdings of foreign capital will be built up by capitalists, at the expense of domestic investment. Such an outcome fits the experience of a number of developing countries, particularly in Latin America.

Notice, furthermore, that the behavior of both sets of players lends itself to a simple interpretation. Both use analogous consumption rules in all equilibria we study. In this case, workers' consumption can be written as $w_t=[(a-\alpha)(1-\sigma)+\sigma\delta]k_t$, where

$(a-\alpha)$ is the net return enjoyed by workers from the capital stock.[11] Note that the term in square brackets is identical to β, given the value of α computed above. Capitalists use an equivalent rule, as can be seen in (9) substituting $(a-\alpha)$ with r, the return earned by capitalists.

This consumption function, coupled with the postulated utility function, can be integrated to yield the following

$$U_j = \frac{\sigma}{\sigma-1} k_0^{\frac{\sigma-1}{\sigma}} [return_j(1-\sigma)+\delta\sigma]^{-\frac{1}{\sigma}} \qquad j=w,k \tag{13}$$

where "$return_j$" is the net return obtained by player j along a given equilibrium path. This expression implies that welfare will be an increasing function of the return enjoyed by each player, regardless of the value of σ. This means that when checking whether it pays off to deviate from a given path, it is enough to check whether by doing so a group could secure a higher return.

Next we do exactly that, showing that the above trajectory is indeed a subgame perfect equilibrium. By construction, consuming $w_t=[(a-\alpha)(1-\sigma)+\sigma\delta]k_t$ if the capitalists are withdrawing αk_t is a best response from the point of view of workers. From the point of view of capitalists, the overall return to investment they obtain along this path is r, which is exactly what they would obtain on the margin if they deviated by taking more capital out. Since welfare is simply an increasing function of the return obtained, it does not pay to deviate.

Finally, by substituting the relevant returns enjoyed along

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[11] Of course, workers do not own the capital stock, but still have to worry about how much will be available for their future consumption.

this equilibrium into (13) we obtain

$$U_w^i = \frac{\sigma}{\sigma-1} k_0^{\frac{\sigma-1}{\sigma}} [a-r]^{-\frac{1}{\sigma}}$$

$$U_k^i = \frac{\sigma}{\sigma-1} k_0^{\frac{\sigma-1}{\sigma}} [r(1-\sigma)+\delta\sigma]^{-\frac{1}{\sigma}} \tag{14}$$

where "i" stands for "interior"[12] Inspection of (14), recalling Proposition 1, leads to

<u>**Proposition 2**</u>**: Capitalists are better off than workers if the equilibrium involves capital flight. If not, workers are better off than capitalists. If (12) holds with equality, the welfare of both groups is the same.**

Some intuition is provided by noting that (12) can be written as $[r(1-\sigma)+\sigma\delta]>[a-r]$. The L.H.S. is the rate at which capitalists consume per unit time, while the R.H.S. is the rate at which workers consume. Hence, if this condition is met and $\sigma<1$ capitalists are better of than workers, and viceversa.

How can capitalists ever be worse off than workers if they are in the privileged position of being able to invest abroad? The answer is that when capital is mobile, workers can always drive the

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[12] A careful reader might be puzzled by the observation that as r goes to a, the welfare of workers goes to zero, while the expression for capitalists' welfare is negative if $\sigma<1$. Thus, it would seem that workers are better off in that case, contradicting the intuition that if capitalists can move abroad with no cost (a=r), they will always be better off than workers. The answer to this apparent paradox is that the above interior equilibrium is only defined if a is strictly above r --see the transversality conditions in the appendix.

return available to capitalists down to r, the rate of return abroad. If r is small, so that condition (12) is not satisfied, the portion captured by workers is relatively large. Furthermore, in this case the amount the capitalists withdraw from the capital stock is less than what they wish to consume. Hence, they must borrow abroad to finance their consumption (f_t becomes negative). Such a combination of circumstances favors workers, raising their total welfare above that of capitalists.

III. The extreme equilibria

Extreme equilibria happen when shocks to expectations lead capitalists to invest at either the minimum or maximum allowable rates. The "pessimistic" equilibrium occurs when capitalists expect that workers will consume more than what is given by (8). In this case it is a best response for capitalists to remove from the capital stock more than is implied by (9). Similarly, if the workers expect that the capitalists will take out more than along the interior path, it may be a best response for workers to increase their own consumption. Hence, pessimistic expectations can become self-fulfilling, possibly leading to a run on the domestic capital stock.

Along the pessimistic path the capitalists will invest at the lowest possible rate: $I_t=\underline{\theta}k_t$. For the interior equilibrium to exist we must assume that $\underline{\theta}$ is "small", in that $\underline{\theta}<(\sigma/(1-\sigma))(a-r-\delta)$.[13] Recall that the right-hand side of this inequality is the rate at which capital is accumulated (or deccumulated) along the interior equilibrium. Hence, along a pessimistic path capitalists must be investing less than in the interior equilibrium.

[13] Indeed, $\underline{\theta}$ could well be negative, so that capitalists are actually disinvesting along this path.

The problem solved by capitalists and workers remains the same. Workers use a rule of the form $w_t=\gamma k_t$, and capitalists follow policy rule $z_t=\pi k_t$. For the latter, it must be the case that, since the investment constraint is binding, the multiplier $\underline{\omega}>0$. As in the previous section, we characterize the path followed by the economy if capitalists are investing at the minimum rate, and then ask whether this is an equilibrium.

The appendix shows that if the capital stock is growing at $\underline{\theta}$ percent per unit time, it follows that

$$\gamma = \delta+\left(\frac{1-\sigma}{\sigma}\right)\underline{\theta} \tag{15}$$

$$\pi = a-\delta-\frac{\underline{\theta}}{\sigma} \tag{16}$$

$$c_t = [r(1-\sigma)+\sigma\delta]\,[f_t+\underline{q}k_t] \tag{17}$$

where

$$\underline{q} = \frac{a-\delta-\dfrac{\underline{\theta}}{\sigma}}{r-\underline{\theta}} \tag{18}$$

This last expression can be interpreted as the shadow value of one unit of capital, from the capitalists' point of view.

When is this a Nash equilibrium? If capitalists are playing according to (16), it is always a best response for workers to play according to (15). What about viceversa? In this trajectory, the return to capitalists from investing at home is $a-\gamma=a-\delta-((1-\sigma)/\sigma)\underline{\theta}$. For this to be an equilibrium, that must be less than r --only then it pays to disinvest at the maximum rate. Some manipulation reveals that this condition is only met if $\sigma>1$.

The intuition for this result is simple. The workers' rule can be written as $\gamma=[(a-\pi)(1-\sigma)+\sigma\delta]$. Hence, if $\sigma<1$, workers' consumption moves inversely with π. That is to say, the more the capitalists extract from the domestic pool, the higher the return they obtain from investing there. For it to pay off to extract at the maximum rate, it must be the case that at the boundary the capitalists are getting less than r from investing inside. But this cannot be the case, given the inverse relationship between w_t and π. Hence, if $\sigma<1$, the extreme outcome cannot be an equilibrium.

The appendix also shows that

$$U_W^p = \frac{\sigma}{\sigma-1} k_0^{\frac{\sigma-1}{\sigma}} [\delta+(\frac{1-\sigma}{\sigma})\underline{\theta}]^{-\frac{1}{\sigma}}$$

$$U_K^p = \frac{\sigma}{\sigma-1} k_0^{\frac{\sigma-1}{\sigma}} [r(1-\sigma)+\delta\sigma]^{-\frac{1}{\sigma}} (\underline{q})^{\frac{\sigma-1}{\sigma}} \tag{19}$$

where the "p" denotes "pessimistic."

Comparing (14) and (19), and noting that $\underline{q}<1$ (details are in the appendix), we see that welfare is always lower along the pessimistic path than in the interior equilibrium.

The above discussion, conducted in terms of the pessimistic outcome, is also applicable to an extreme optimistic equilibrium, along which capitalists invest at the maximum allowable rate. In that path, the behavior of both sets of players is governed by equations (15)-(18), now replacing $\underline{\theta}$ by $\overline{\theta}$. In this case, the path is an equilibrium only if the return on domestic capital obtained by capitalists is less than r. For the same reasons as before, this can only be the case if $\sigma>1$.

Welfare in the optimistic equilibrium is once again given by (19), with $\overline{q}$ replacing $\underline{q}$. Since $\overline{q}>1$, welfare must be higher than in the interior path. These considerations can be summarized in

<u>Proposition 3</u>: **Extreme equilibria can exist only if $\sigma>1$. In the pessimistic equilibrium, both sets of players are always worse off than in the interior equilibrium. In the optimistic one, both are better off.**

IV. <u>The Case of Capital Controls</u>

What happens if the capital account is closed, so that capitalists are prevented from ever holding foreign capital? Will this yield more investment at home? Will it make one or both groups better off? In what follows we limit comparisons to the interior equilibrium discussed above.

In the case of a closed capital account, the conflict is limited to the consumption paths financed out of domestic output. Workers maximize (1) with respect to w_t, subject to (2) and the rule followed by capitalists. These maximize (1') with respect to I_t, subject to constraints analogous to those faced by workers.

It turns out that in such a situation both groups become symmetric. Since now z_t is identical to capitalists' consumption, we have that $c_t=w_t=z_t=\rho k_t$, where ρ is to be determined endogenously. Notice that both groups still use state-dependent strategies. The workers' Hamiltonian is

$$H^w = \frac{\sigma}{\sigma-1}(w_t)^{\frac{\sigma-1}{\sigma}} + \lambda[(a-\rho)k_t - w_t] \tag{20}$$

which is maximized with respect to w_t. The capitalists' Hamiltonian is

$$H^k = \frac{\sigma}{\sigma-1}(c_t)^{\frac{\sigma-1}{\sigma}} + \lambda[(a-\rho)k_t - c_t] \tag{21}$$

to be maximized with respect to c_t. The solution to this problem can be obtained by a method equivalent to that used in the last two sections. It leads to

$$w_t = c_t = \frac{[a(1-\sigma)+\delta\sigma]}{2-\sigma} k_t \tag{22}$$

$$k_t = k_o e^{\frac{\sigma(a-2\delta)}{2-\sigma}t} \tag{23}$$

so that $\rho=[a(1-\sigma)+\sigma\delta]/(2-\sigma)$.

Equation (22) shows the rate at which workers and capitalists consume per unit time. It once again has the shape of a usual consumption function, in that it can be written as $\rho=[(a-\rho)(1-\sigma)+\sigma\delta]$. Such consumption behavior yields a path for the capital stock described by (23).

The absence of capital flight, it might be thought, will enhance domestic investment. The fact that capitalists will now place all their resources at home would certainly point in this direction. On the other hand, since returns will now change consumption patterns will also do so. If consumption by both groups rose sufficiently, domestic investment could actually fall.

A comparison of expressions (10) and (23) leads to

<u>Proposition 4</u>: **If the interior equilibrium is characterized by capital flight, then the path under capital controls displays higher domestic investment than the interior path. If not, it displays less domestic investment. If (12) holds with equality, then investment is the same in both paths.**

What about welfare? The appendix shows that

$$U_j^C = \frac{\sigma}{\sigma-1}(k_0)^{\frac{\sigma-1}{\sigma}}\left[\frac{a(1-\sigma)+\delta\sigma}{2-\sigma}\right]^{-\frac{1}{\sigma}} \qquad j=w,k. \tag{24}$$

where the "c" stands for "controls." This expression, compared with (14), shows that

<u>Proposition 5</u>: **If (12) is not satisfied, capitalists are better off under controls than along the interior equilibrium. Workers are worse off if $\sigma<1$, but better off if $\sigma>1$. The opposite holds if (12) is satisfied. If (12) holds with equality, there is no change in welfare.**

The intuition for these results is simple. For capitalists to be better off, they must be obtaining a return that is at least as large as r. Here the return to capitalists is a-ρ. This is larger than r if (12) is not met. In that case, capitalists gain. The expectation of no capital flight contributes to reassure workers that capitalists will not act rapaciously. In turn, this leads workers to behave less aggressively, thus making capitalists better off.

An analogous logic applies to the return obtained by workers. It is easy to check that along this trajectory the return available to workers is lower than in the interior equilibrium if $\sigma<1$, and higher if $\sigma>1$.

Hence, capital controls are only Pareto improving if (12) is not satisfied and $\sigma>1$ (note that this is one case in which the interior equilibrium does not display capital flight). At the same time, this is also a situation in which the optimistic path described above can be an equilibrium --and if $\bar{\theta}$ is large enough, the optimistic path should yield higher welfare than the controls path. In that case, a government's best policy is not to impose controls, but to attempt to coordinate expectations in order to place the economy on the optimistic equilibrium.

5. Conclusions

This paper shows that domestic underinvestment and capital flight can be the outcome of a non-cooperative dynamic game between capitalists and workers. Indeed, the interior equilibrium of our game is reminiscent of the experience of several developing countries. For some parameter values, the domestic economy becomes gradually "decapitalized," while entrepreneurs build up holdings of foreign assets.

That interior equilibrium is not the only possible outcome, however. Animal spirits can also trigger outcomes along which capitalists invest at either the minimum or the maximum rate. In the case of the pessimistic equilibrium, for instance, capitalists --expecting that workers will act aggressively and consume more than along the interior equilibrium-- rush to extract resources from the domestic stock as fast as possible. Such pessimistic expectations can be self-fulfilling if the elasticity of intertemporal substitution in consumption is larger than unity. If this "extreme" outcome occurs, both groups lose welfare relative to the interior outcome. The opposite occurs if optimistic expectations prevail. In that case capitalists invest swiftly, and workers reciprocate by moderating their wage demands, leading to a welfare gain for all.

Hence, the economy seems vulnerable to expectational shifts, and can settle on vastly different paths depending on the prevailing animal spirits. At the same time, the extreme equilibria can only occur if the elasticity of intertemporal substitution in consumption is larger than unity. Given existing empirical estimates, this condition may well fail to be met. Hence, the interior equilibrium is the likeliest outcome to the game between capitalists and workers.

Confronted with such a situation, central banks are often tempted to impose capital controls. For simplicity, we only compare the controls outcome to the interior equilibrium of the unconstrained game. We find that capital controls can, for some parameter values, enhance the domestic investment rate. Nonetheless, they also have sharp distributional effects. In some cases, we obtain the intuitive result that controls raise the welfare of workers and reduce that of capitalists. In other cases, however, controls can help capitalists commit to a future course of action, actually making them better off.

APPENDIX

1. The Closed-Loop Nash Solution

Here we compute the interior equilibrium to the game between capitalists and workers. We restrict ourselves to state-dependent strategies. Workers maximize

$$U^w = \int_o^\infty \left(\frac{\sigma}{\sigma-1}\right)(w_t)^{\left(\frac{\sigma-1}{\sigma}\right)} e^{-\delta t}\, dt \tag{1A}$$

where variables are defined as in the text. Recall we do not allow for σ=1. Workers' budget constraint is

$$\dot{k}_t = ak_t - w_t - z_t = I_t \tag{2A}$$

The capitalists, on the other hand, maximize

$$U^k = \int_o^\infty \left(\frac{\sigma}{\sigma-1}\right)(c_t)^{\left(\frac{\sigma-1}{\sigma}\right)} e^{-\delta t} dt \tag{3A}$$

subject to (A2) and

$$\dot{f}_t = rf_t + z_t - c_t \tag{4A}$$

We also require

$$\underline{\theta}k_t \le I_t \le \bar{\theta}k_t, \qquad k_t \ge 0 \qquad c_t > 0 \qquad w_t > 0 \qquad \forall t \tag{5A}$$

$$k_{t=0} = k_o \qquad\qquad f_{t=0} = 0 \tag{6A}$$

For given policy rules $w_t=\beta k_t$ and $z_t=\alpha k_t$, the worker's Hamiltonian is

$$H^{w} = \frac{\sigma}{\sigma-1}(w_t)^{\frac{\sigma-1}{\sigma}} + \lambda[(a-\alpha)k_t - w_t] \tag{7A}$$

where λ is the costate variable associated with k. Workers maximize this Hamiltonian with respect to w_t. The corresponding first order conditions are

$$(w_t)^{-\frac{1}{\sigma}} = \lambda_t \tag{8A}$$

$$\lambda_t = \lambda_t[\delta - a + \alpha] \tag{9A}$$

plus the transversality condition

$$\lim_{t\to\infty} \lambda_t k_t e^{-\delta t} = 0 \tag{10A}$$

which combined yield

$$\dot{w}_t = w_t[a-\alpha-\delta] \tag{11A}$$

Of course, the workers' problem is coupled to the capitalists'. Their Hamiltonian is

$$H^{k} = \frac{\sigma}{\sigma-1}(c_t)^{\frac{\sigma-1}{\sigma}} + \mu_t I_t + \phi_t[rf_t + (a-\beta)k_t - I_t - c_t] + \overline{\omega}_t[\overline{\theta}k_t - I_t] + \underline{\omega}_t[I_t - \underline{\theta}k_t] \tag{12A}$$

where μ_t and ϕ_t are the costate variables associated with k_t and f_t respectively, and the ω's are the multipliers associated with the inequality constraints. Capitalists maximize (12A) with respect to c_t and I_t. The first order conditions are

$$c_t^{-\frac{1}{\sigma}} = \phi_t \tag{13A}$$

$$\mu_t - \phi_t + \underline{\omega}_t - \overline{\omega}_t = 0 \tag{14A}$$

$$[I_t - \underline{\theta} k_t]\,\underline{\omega}_t \geq 0, \qquad \underline{\omega}_t \geq 0 \tag{15A}$$

$$[\overline{\theta} k_t - I_t]\,\overline{\omega}_t \geq 0, \qquad \overline{\omega}_t \geq 0 \tag{16A}$$

$$\dot{\mu}_t = \mu_t \delta + \phi_t [\beta - a] + \underline{\omega}_t \underline{\theta} - \overline{\omega}_t \overline{\theta} \tag{17A}$$

$$\dot{\phi}_t = \phi_t [\delta - r] \tag{18A}$$

plus the transversality conditions

$$\lim_{t \to \infty} \mu_t k_t e^{-\delta t} = 0 \tag{19A}$$

$$\lim_{t \to \infty} \phi_t f_t e^{-\delta t} = 0 \tag{20A}$$

2. The interior equilibrium

This set of first order conditions can generate three cases. The first is an interior one, along which the corner constraints are not binding. In that case, $\underline{\omega}=\overline{\omega}=0$. We characterize this path first.

From (13A) and (18A) we get that

$$\dot{c}_t = c_t\, \sigma [a - \beta - \delta] \tag{21A}$$

while from (17A) and (18A) it follows that

$$\beta = a - r \tag{22A}$$

We must now solve for α. Taking time derivatives of both sides of the workers' policy rule and substituting in (2A), both policy rules and (11A) we have

$$w_t = \frac{\beta(a-\beta-\alpha)}{\sigma(a-\delta-\alpha)}\,k_t \tag{23A}$$

Recalling again the workers' rule, (22A) and (23A) we conclude that

$$\alpha = \frac{r-\sigma(a-\delta)}{1-\sigma} \tag{24A}$$

In equilibrium, capitalists' consumption will also be a linear function of the state variables. To show this we use the method of undetermined coefficients. Let $c_t=\psi[k_t+f_t]$, where ψ is a constant coefficient. Take time derivatives of both sides of this rule, and substitute in (2A), (4A), (21A), (22A) and (24A). This yields $\psi=[r(1-\sigma)+\sigma\delta]$, or

$$c_t = [r(1-\sigma)+\sigma\delta]\;[k_t+f_t] \tag{25A}$$

We can use these results to calculate the trajectories of the state variables as well. Substituting (22A), (24A) and (25A) into (2A) and integrating we obtain

$$k_t = k_o e^{\frac{\sigma}{\sigma-1}[r+\delta-a]\,t} \tag{26A}$$

To solve for f_t, substitute the capitalists' rule, (24A) and (25A) into (4A) and integrate. The result is

$$f_t = [e^{\sigma(r-\delta)t}-e^{\frac{\sigma}{\sigma-1}(r+\delta-a)t}]\,k_o \tag{27A}$$

It only remains to check that these trajectories satisfy transversality conditions (10A), (19A) and (20A). Substituting (9A) and (26A) into (10A) and integrating we obtain

$$\lim_{t\to\infty} \lambda_o k_o e^{-(a-r)t} = 0 \tag{28A}$$

Hence, this condition requires that a>r, as we assumed above.

Similarly, substituting (17A), (22A) and (26A) into (19A) and integrating we have

$$\lim_{t\to\infty} \mu_o k_o\, e^{-\frac{[r-\sigma(a-\delta)]}{1-\sigma}t} = \mathit{limit}_{t\to\infty}\, \mu_o k_o\, e^{-\alpha t} = 0 \tag{29A}$$

We require that $\alpha>0$ for this condition to hold. In other words, z_t will always be positive, and capitalists will never remove resources from their foreign holdings to invest them at home.

Substituting (18A) and (27A) into (20A) and integrating yields

$$\lim_{t\to\infty} \phi_o k_o [e^{-[r(1-\sigma)+\sigma\delta]t} - e^{-\alpha t}] = 0 \tag{30A}$$

which always holds given our previous assumptions.

Finally, one can substitute the capitalists' rule, (21A), (25A) and (26A) into the objective functions (1A) and (3A) to obtain the welfare levels associated with this equilibrium. Integration yields

$$U_W^i = \frac{\sigma}{\sigma-1} k_0^{\frac{\sigma-1}{\sigma}} [a-r]^{-\frac{1}{\sigma}}$$

(31A)

$$U_K^i = \frac{\sigma}{\sigma-1} k_0^{\frac{\sigma-1}{\sigma}} [r(1-\sigma)+\delta\sigma]^{-\frac{1}{\sigma}}$$

3. The extreme equilibria

Consider now the extreme cases, starting with the pessimistic outcome at which capitalists invest at the feasible minimum percentage rate $\underline{\theta}$. In this case, of course, $\overline{\omega}=0$. Define a variable $q_t=\phi_t/\mu_t$. Then, by (17A)-(18A) we have

$$\dot{q}_t = q_t(r-\underline{\theta})-(a-\gamma-\underline{\theta}) \qquad (32A)$$

This q_t can be interpreted as the value of one unit of capital (in terms of the consumption good) from the capitalists' point of view. Because a, r, γ and θ are constants, integrating forward we obtain

$$q = \frac{a-\gamma-\underline{\theta}}{r-\underline{\theta}} \qquad (33A)$$

To obtain γ one can use the following procedure. Assume that the capitalists follow policy rule $z_t=\pi k_t$. If it is indeed the case that they are investing at the minimum rate, then it follows from (2A) that

$$\underline{\theta} = a-\gamma-\pi \qquad (34A)$$

By analogy with the previous cases and with the standard consumption problem, the workers' rule will be

$$\gamma = [(a-\pi)(1-\sigma)+\sigma\delta] \qquad (35A)$$

Combining these last two equations one obtains

$$\gamma = \delta+\left(\frac{1-\sigma}{\sigma}\right)\underline{\theta} \qquad (36A)$$

so that

$$w_t = \left[\delta+\left(\frac{1-\sigma}{\sigma}\right)\underline{\theta}\right]k_t \qquad (37A)$$

Finally, substituting (36A) into (35A) we get

$$\pi = a-\delta-\frac{\underline{\theta}}{\sigma} \qquad (38A)$$

Notice that given (33A) and (36A) it follows that

$$\underline{q} = \frac{a-\delta-\frac{\underline{\theta}}{\sigma}}{r-\underline{\theta}} \tag{39A}$$

For later purposes it is important to establish whether $\underline{q}$ is larger or smaller than one. Recall from the transversality conditions above (equation 29A) that we require $\alpha>0$ for the interior equilibrium to exist. Recall, furthermore, that $\underline{\theta}<(\sigma/(1-\sigma))(a-r-\delta)$, These two conditions and some simple manipulation suffice to show that $\underline{q}>1$ if $\sigma<1$, and $\underline{q}<1$ if $\sigma>1$.

Using the method of undetermined coefficients, as in section 2 of this appendix, one can show that

$$c_t = [r(1-\sigma)+\sigma\delta]\ [f_t+\underline{q}k_t] \tag{40A}$$

These results yield

$$U_W^P = \frac{\sigma}{\sigma-1} k_0^{\frac{\sigma-1}{\sigma}} [\delta-(\frac{1-\sigma}{\sigma})\theta]^{-\frac{1}{\sigma}}$$

(41A)

$$U_k^P = \frac{\sigma}{\sigma-1}\ k_0^{\frac{\sigma-1}{\sigma}} [r(1-\sigma)+\delta\sigma]^{-\frac{1}{\sigma}}\ (\overline{q})^{\frac{\sigma-1}{\sigma}}$$

Two conclusions follow from these expressions. The first concerns capitalists' welfare. Comparing (31A) and (41A) we see that if $\sigma>1$ (the only relevant case), capitalists are worse off than in the interior equilibrium if $q<1$, a condition that we know holds whenever $\sigma>1$. A similar analysis reveals that workers are always worse off as well. Hence, both groups are worse off than in the interior equilibrium.

The optimistic equilibrium is analogous to the pessimistic one. In that case, $\underline{\omega}=0$. We therefore replace $\underline{\theta}$ with $\overline{\theta}$ everywhere, and this gives rise to a $\overline{q}$ to replace q. For the exercise to make sense, we need $\overline{\theta}>(\sigma/(1-\sigma))(a-r-\delta)$. In contrast to the pessimistic case, this means that $\overline{q}<1$ if $\sigma<1$, and $\overline{q}>1$ if $\sigma>1$. Given an amended version of (41A) with, $\overline{q}$ replacing q, this means that welfare is higher for both groups than under the interior equilibrium.

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