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INTERNATIONAL FISCAL COORDINATION UNDER IMPERFECT INFORMATION *

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This study investigates the issue of optimal fiscal policies and international fiscal coordination across economies in the world of uncertainties and imperfect information. It lays out the strategic problems of coordination that we inevitably encounter when the integration of international capital markets is a reality and when we do not have enough information about other countries. In this international environment, the results show that there exists a precommitment mechanism with non-cooperative dynamic equilibria, which would render us a higher level of welfare than the non-coordiation outcome. In these equilibria, the phases of low outcomes with high interest rates will appear intermittently between the phases of high outcomes with low interest rates. Under the proposed system, the results indicate that welfare will be reduced as uncertainty increases, whereas the gains from adopting this proposed mechanism will grow as the number of countries with open capital markets increases.

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I. INTRODUCTION

In this world of high integration and capital mobility, the decisions of others can easily affect our lives. Any subtle changes in conditions, outlook of the economy or the behavior of neighboring governments can immediately attract or draw away a huge flow of capital overnight, consequently making the rates of returns equal wherever investors are putting their money in. With these sensitively mobile capital flows, the actions of others have real effects on the home economy, which in turn influence our decision-making. As the world eliminates the existing trade barriers and the impediments of capital markets, the impact of one country's policies on the well-being of others magnifies to the extent that makes any country difficult to ignore. With this externality effect in mind, each country will strategically set its policies, which will bring us to suboptimal outcome, when we consider the world as a whole. More specifically, when we consider a country's fiscal policy and the determination of the level of budget deficits, we would expect the country's choice of budget deficit levels to be larger than its optimal level. Thus, a need for policy coordination among countries has been introduced to the center stage of recent discussions.

In a world where capital is perfectly mobile across countries, there exists only one interest rate for all countries. Any change in a country's rate would immediately attract capital, which in turn, would bring the rates to the same equilibrium level. A country inevitably has influences over this rate when choosing its own domestic policies. When one country determines its fiscal policy and the level of government spending, it also has to choose the method of financing. When the financing involves issuing government bonds or some other forms of debt promising to pay back in the future, the interest rate is correlated with the total amount of debt the government issued. When one country engages in issuing a certain sum of bonds, we expect the world interest rate to rise, leaving other countries with a higher burden of debt.

In an article by Chang(1990), the author provides an overlapping generation dynamic equilibrium model where international externalities result in inefficiently large fiscal deficits, high interest rates, or low levels of welfare, when international fiscal policy coordination is absent. Chang also shows that the cooperative outcome, where each country chooses the cooperatively optimal (low) level of budget deficits, can be supported in a non-cooperative world by introducing a trigger strategy mechanism where all countries punish any possible deviation by taking a non-cooperative deficit level in the next period and onward. This setting would allow us to enjoy the optimal level of budget deficits and interest rate, without any deviation or sudden changes.

However, in the actual world, a country faces uncertainties and shocks, much of which are unforeseable. When we consider that a government's budget is primarily financed by the taxes raised from indiviuals and by government bonds, we can be left with a huge or small level of budget deficits at the end of the day. This depends on how the economy unveils itself and on the size of the tax revenues, in the presence of these uncertainties. Even though we may carefully make projections about the future, design tax rates, and plan the amount of the bonds to be issued, we will always end up with more or less national debt than the expected level. Given available information, the best we can do in advance is to estimate the performance of the economy and optimally set the budget and the expected deficit level in the process. Suppose, for example, there is a common optimal size of budget deficits for all cases. We may plan to expand the budget, when the prospect of the future looks rosy and do the opposite when it is obscure, to keep the realized deficit around the optimal size.

The problem of sustaining the cooperatively optimal fiscal policies through coordination surges when the home country has a better set of information about the outlook of its own economy than others. Chang(1990) shows that a country will prefer to choose a higher level of deficits without coordination, and the punishment will prevent the deviation from the optimally coordinated policy. However, as each country sets the level according to what they project, they can expand the level and rationalize its action by pretending that the outlook is better than what they actually see. Obviously, in the following day, they would be far off from the pretended prospect and joyfully left with a higher level of deficits than the coordinated level. Nevertheless, it cannot be impeached, *ex post*, by others in the manner suggested by Chang, since there is no way to accurately distinguish whether it was a breach of the agreement or not (as the home country has the best information about its own course, *ex ante*, and the realization can be only seen at the end of the period). This implies that the above supported cooperative equilibrium cannot be realized, as stated, in a more realistic and probable environment. We would be left with inefficient levels of fiscal deficits and high interest rates.

A similar issue has been the focus of discussion in the context of time inconsistency in monetary policies. Rogoff(1985) and Barro and Gordon(1983) extend the discussion of the time inconsistency problem, in Kydland and Prescott(1977), to the model of uncertainty. However, Canzonneri(1985) points out that the solutions and explanations for achieving the efficient outcome break down when the government has private information. Canzonneri(1985) discusses the role of asymmetric information in the monetary policy and the incentives to misrepresent the private information, as we have discussed above. He adopts Green and Porter's(1984) model to explain how players may be already at a better equilibrium.

This paper elaborates on the issue of whether we can do better in setting fiscal policies in the world of uncertainties and imperfect information. It lays out the strategic problems of the coordination we inevitably encounter, when the integration of international capital markets is a reality and when we do not have enough information about other countries. It searches for a coordination mechanism which will allow us to have a better welfare status than the status quo. Green and Porter(1984) discuss a similar optimal cartel problem in the industry with imperfect information. Their results suggest that when a certain level of price is sustained, we continue to have the high period, whereas, when realized prices are low, everyone expands the output for some periods to punish the possible deviation. In this international environment, the results analogous to theirs show that there exists a 'precommitment' mechanism with non-cooperative dynamic equilibria, which would render us a higher level of welfare for most cases, when the discount rate is not too high.[1] In

[1] The term "precommitment" is used in this study to be consistent with the previous studies in the literature such as Kydland and Prescott (1977), Canzonneri (1985) and Chang (1990).

these equilibria, the phases of low outcomes with high interest rates will appear intermittently between the phases of high outcomes with low interest rates. Furthermore, it is shown that when the hazard rate of any distribution of the shock is not too small for some realizations, there always exists a precommitment equilibrium. Under the proposed system, the results indicate that the more uncertain the world is, the worse off it will be. The gains from adopting this proposed mechanism will grow as the number of countries with open capital markets increases.

In the coming era, unless we share symmetric and verifiable information on the outlook of each country's economy among the countries with open capital market, it would be difficult to achieve the goal of policy harmonization. Despite the efforts by G-7 and EU countries to harmonize their policies, this paper suggests that more countries should be involved in the table talks of coordination and further proposes, either to strengthen the monitoring and information gathering activity to observe the decision processes of others (possibly through the operations of IMF) or to adopt the proposed precommitment system to bring us to a higher level of welfare.

The organization of the paper is as follows. In Section 2, a simple multi-country overlapping generations model is presented as a baseline model. Section 3 compares the non-coordination and the coordination outcomes based on strategic fiscal decisions of each country. Due to imperfect information, the coordination equilibrium is shown to be impossible to implement. Section 4 explores the possibility of introducing a non-cooperative precommitment mechanism, which is incentive compatible and Pareto-superior to the non-coordination rule. Section 5 is devoted to the comparative statics. Section 6 concludes the paper.

II. THE MODEL

We modify the model in Chang(1990) to incorporate information imperfection. The base model is a simple multi-country overlapping generations model, with no growth, no productive capital, and only one consumption good which is produced with linear technology. Population and resources of all countries are assumed to be identical, and the only differences are the choice of government expenditures and taxes. Each generation lives for two periods, and all generations are identical. The exception is that generation zero is born, old at period 1 and live only during the remaining one period. We denote the representative agent of the generation born at, *t*, in country, *i*, as agent (*i*, *t*), who works only in the first period for n_{it} hours and consumes the good in her second period. Since there are uncertainties involved in the second period, we assume agent (*i*, *t*) chooses n_{it} to maximize her expected utility which is given by:

$$E[U(n_{it}, C_{i,t+1})] = KE[C_{i,t+1}] - n_{it}^2/2, \tag{1}$$

where K is a constant and $C_{i,t+1}$ represents the second-period consumption. The second-period consumption $C_{i,t+1}$ consists of three components. First, the output from the first period labor will be saved in the government bonds b_t, which will have a gross real rate of returns of R_t .[2] The bonds will be paid back one-period later with new bonds amount to $R_t b_t$. These new bonds will allow the agent to buy the good for consumption in the second period. Second, everyone has a tree which bears fruit in the second period in an uncertain amount of $\theta_{i,t+1} + \varepsilon_{i,t+1}$. At the beginning of each period, only one portion of the uncertainty factors, $\theta_{i,t+1}$, is resolved and the rest remains as a stochastic component. To say that each country and its agents know more about their own situation than others in the model, we assume that $\theta_{i,t+1}$ is only perceived by its own country and its agents. Country i has private information about $\theta_{i,t+1}$ at the decision making moment, whereas other countries consider whole $\theta_{i,t+1} + \varepsilon_{i,t+1}$ as a stochastic term. At the end of each period, only the resulting values of $\theta_{i,t+1} + \varepsilon_{i,t+1}$ are revealed. For simplicity, we normalize these uncertainties having prior distribution of mean zero and variance of σ_θ^2 and σ_ε^2, which are common knowledge. Third, at the beginning of each period the government determines the lump sum transfers to the old generation in the amount of $\tau_{i,t+1}$ at t +1. They are given newly issued bonds in the amount of $\tau_{i,t+1}$, which is used to buy the good in the second period. Therefore, agent (*i*, *t*)'s budget

[2] The model is described in terms of government-issued bonds. However, any other types of governement debt with interest payment will work for our purposes.

constraint is as follows:

$$C_{i,t+1} = R_t(1-t_l)n_{it} + (1-t_p)(\theta_{i,t+1} + \varepsilon_{i,t+1}) + \tau_{i,t+1}, \tag{2}$$

where t_l and t_p are taxes on labor and fruit (assumed to be symmetric across countries for simplicity).

The government budget consists of two parts. The government issues one-period bonds for two purposes. First, as mentioned previously, the central government commits to the level of a lump sum transfer $\tau_{i,t+1}$ to agent (i, $t+1$) at time $t+1$, and these new bonds are given to the old generation in the commensurate amount of transfer, which is then exchanged with the good provided by the young. The second is related to the operation of the government. The planned government expenditure besides lumpsum transfers is set at $g_{i,t+1}$ and will be financed by the raised taxes $t_l n_{i,t+1} + t_p(\theta_{i,t+1} + \varepsilon_{i,t+1})$, which has uncertainty factors $\theta_{i,t+1}$ and $\varepsilon_{i,t+1}$. The resulting deficit will be covered by issuing new bonds, $\eta_{i,t+1}$.

$$\eta_{i,t+1} = g_{i,t+1} - t_l n_{i,t+1} - t_p(\theta_{i,t+1} + \varepsilon_{i,t+1}) \tag{3}$$

Therefore, the total amount of the government bonds to be issued, $b_{i,t+1}$, comprises of the amount needed to pay back the bonds issued one period earlier, $R_{i,t}b_{i,t}$, and the amount to cover the transfer $\tau_{i,t+1}$ and the deficit $\eta_{i,t+1}$.

$$\lambda_{i,t+1} = \tau_{i,t+1} + \eta_{i,t+1} \tag{4}$$

$$b_{i,t+1} = R_{i,t}b_{i,t} + \lambda_{i,t+1}, \tag{5}$$

where $\lambda_{i,t+1}$ is the total amount of fiscal deficits at period $t+1$.

The story goes as follows. Given the tax rates and private information about θ_{it}, each government chooses its own level of transfers and government expenditures. Subsequently, the tree bears fruit, and the uncertainty portion ε_{it} is realized. Given all the information, the agents choose their labor hours to maximize their expected utilities. The exchange of bonds and goods is followed by the final consumption of the good. In this model, as we do not have $g_{i,t+1}$ entered anywhere as a term in the utility function, we assume that it is set at the minimal level g. Let $t_p = t$. Then the equations (2) and (3) becomes:

$$C_{i,t+1} = R_t(1-t_l)n_{it} + (1-t)(\theta_{i,t+1} + \varepsilon_{i,t+1}) + \tau_{i,t+1} \tag{6}$$

$$\eta_{i,t+1} = g - t_l n_{i,t+1} - t(\theta_{i,t+1} + \varepsilon_{i,t+1}) \tag{7}$$

Given the constraints, the optimal labor hours for the agent is:

$$n_{it} = (1-t_l)KR_t$$

The equilibrium gross real rate of return will be determined by the bond market clearing condition after the occurrence of the shocks. Under perfect international capital mobility, all countries face the same world real interest rate, R_t, which is set in the international capital market.

$$\sum_{i=1}^{N}(1-t_l)n_{it} = \sum_{i=1}^{N} b_{it}$$

$$(1-t_l)^2 NKR_t = R_{t-1}(\sum_{i=1}^{N} b_{i,t-1}) + \sum_{i=1}^{N}\lambda_{it}$$

$$R_t = \frac{1}{(1-t_t)NK}(y_t + \sum_{i=1}^{N}\tau_{it} + Ng - t(\sum_{i=1}^{N}(\theta_{it} + \varepsilon_{it})), \tag{8}$$

where we can describe the state of the world economy at t by y_t, which is defined to be the world debt service $R_{t-1}(\sum_{i=1}^{N} b_{i,t-1})$ realized at t. Substituting in the chosen level of labor hours, we obtain the indirect utility of each agent.

$$w(R_t, \tau_{i,t+1}) = \frac{1}{2}(1-t_l)^2 K^2 R_t^2 + K(1-t)(\theta_{i,t+1} + \varepsilon_{i,t+1}) + K\tau_{i,t+1} \tag{9}$$

The following definition describes the equilibrium in this environment.

Given the private information, each government sets the budget and commits to the level of transfers at the beginning of each period before the economy unfolds. It chooses τ_{it} to maximize the expected discounted sum of the agent's indirect utility function given the budget constraint (5).

$$W_i(\tau_1,\ldots,\tau_N,y_1) = E_{\theta i}\left[\frac{K((1-t)(\theta_{i1}+\varepsilon_{i1})+\tau_{i1})}{\beta}+\sum_{t=1}^{\infty}\beta^{t-1}w(R_t,\tau_{i,t+1})\right] \tag{10}$$

By defining a derived utility function consisting of only contemporaneous terms, we have the following.

$$U_{it}(\tau_{1t},\ldots,\tau_{Nt},y_t) = \frac{K}{\beta}((1-t)(\theta_{it}+\varepsilon_{it})+\tau_{it})+\frac{1}{2}(1-t_l)^2K^2R_t^2 \tag{11}$$

$$W_i(\tau_1,\ldots,\tau_N,y_1) = E_{\theta i}\left[\sum_{t=1}^{\infty}\beta^{t-1}U_{it}(\tau_{1t},\ldots,\tau_{Nt},y_t)\right] \tag{12}$$

Due to the recursive nature of the formula, we can solve for the optimal τ_{it} in the dynamic programming framework.

III. NON-COORDINATION AND COORDINATION

In the previous studies, Chang(1990) and Espinosa-Vega and Yip(1994) show that since an increase in the government bonds will entail the interest rate to go up, and therefore the debt burden will be shared by the other countries, each country has an incentive to set a higher level of budget deficits than the cooperatively optimal level, when lacking the coordination of policies among the countries. The coordination lowers the level of the world debt and transfers, which results in lower interest rates than those in the non-coordination equilibrium. In this model of uncertainty with private information, we will show that the same results hold. However, a problem arises when we try to enforce the optimal coordination policy. Since the optimal coordination policy inevitably involves each government to respond to the private information and to set the level of deficits accordingly, each country might try to get away with falsely reporting their information θ_{it} to rationalize the increase in the level of τ_{it}. This deviation cannot be detected, *ex post*, since we can only observe the whole result of the event $\theta_{it} + \varepsilon_{it}$, not the independent terms. Therefore, unlike the complete information case, the detection of deviation is impossible, and the punishing mechanism breaks down, which leaves us with the non-coordination outcome.

3.1. Non-coordination

Suppose we are in a non-cooperative world without coordination or precommitment. Each government will act strategically to set its policies to the best of its own interest. In our model, more specifically, each government tries to set τ_{it} to maximize the expected value of the discounted sum of the agent's utility given the strategies of others, τ_{jt}. The following value function gives us the payoff for a non-coordinating country.

$$V_i^n(y_t, \theta_{it}) = \max_{\tau_{it}} E_{\theta_{it}}[U_{it}(\tau_{1t}, \ldots, \tau_{Nt}, y_t) + \beta V_i^n(y_{t+1}, \theta_{i,t+1})] \tag{13}$$

Let's denote $A(\tau_t, y_t) = y_t + \sum_{i=1}^N \tau_{it} + Ng - t\sum_{i=1}^N \theta_{it}$ .Then, we have:

$$E_{\theta_{it}}[U_{it}] = \frac{K}{\beta}((1-t)\theta_{it} + \tau_{it}) + \frac{1}{2}(1-t_l)^2 K^2 E_{\theta_{it}}[R_t^2] \tag{14}$$

$$= \frac{K}{\beta}((1-t)\theta_{it} + \tau_{it}) + \frac{1}{2N^2} A(\tau_t, y_t)^2 \frac{1}{2N} t^2 \sigma_\varepsilon^2 \tag{15}$$

In a non-coordination environment, each country determines it's own optimal policy considering other countrys' policy rules as given. We limit our consideration to policy rules which are linear, symmetric, and depend only on their own shock to minimize the possibility of manipulation. Assuming that all the other countries behave according to

$\tau_{jt}^{n} = \mu_{j}^{n} y_t + \phi_{j}^{n}\theta_{ji} + \gamma_{j}^{n}$, we see that the equilibrium level of budget deficit, interest rate, and the value function will be the following. (We set $\hat{t} = \frac{1-t_l}{1+t_l}$).[3]

$$\tau_{it}^{n} = -\frac{1}{N} y_t + t\theta_{it} + \frac{\hat{t}NK}{\beta} - g \tag{16}$$

$$R_t = \frac{N}{(1+t_l)\beta} - \frac{t}{(1-t_l)NK} (\sum_{i=1}^{N} \varepsilon_{it}) \tag{17}$$

$$V_{it}^{n} = -\frac{K}{N\beta} y_t + \frac{K}{\beta}\theta_{it} + d^{m}, \tag{18}$$

where,

$$d^{n} = -\frac{1}{1-\beta}\left[\frac{\hat{t}N(N-2)K^2}{2\beta^2}\right] - \frac{1}{1-\beta}\left[\frac{K}{\beta} g + \frac{1}{2\hat{t}N} t^2 \sigma_{\varepsilon}^2 - K\overline{\theta}\right] \tag{19}$$

3.2. Coordination

Given the above results, now we seek for the policy rules which will maximize the sum of the welfares of all countries. This will reveal us the magnitude of inefficiency in the non-cooperative setting. We set up a dynamic programming problem which will give us the value function for the world as a whole.

$$V^{c}(y_t, \theta_t) = \max_{\tau_{1t},\ldots,\tau_{Nt}} E_{\theta_t} \sum_{i=t}^{N} U_{it}(\tau_t, y_t) + \beta V^{c}(y_{t+1}, \theta_{t+1})$$

$$V_t^{c} = \sum_{i=1}^{N} V_{it}^{c} \tag{20}$$

The policy rules and the world interest rate satisfying the above

[3] The detailed derivation is available upon request.

problem are given below.

$$\tau_{it}^{c} = -\frac{1}{N} y_t + t\theta_{it} + \frac{\hat{t}K}{\beta} - g \tag{21}$$

$$R_t = \frac{1}{(1+t_l)\beta} - \frac{t}{(1-t_l)NK}\left(\sum_{i=1}^{N} \varepsilon_{it}\right) \tag{22}$$

We notice that τ_{it}^{c} is lower than the non-coordinating τ_{it}^{d}. The reason is that in the non-coordination environment, each country overly increases the deficit since the country's debt burden is shared by the other countries, whereas these externalities are taken into account in setting the budget deficit levels in the coordination environment. Consequently, the interest rate will be realized around the lower value $\frac{1}{(1+t_l)\beta}$, instead of $\frac{N}{(1+t_l)\beta}$. Given the derived policy rules, we are able to obtain separate value functions for the countries. The sum of these resulting value functions for the countries will be Pareto-optimal. The derived value functions, respectively, are larger than the ones in the non-coordination environment, $V_{it}^{c} \geq V_{it}^{n}$.

$$V_{it}^{c} = -\frac{K}{N\beta} y_t + \frac{K}{\beta}\theta_{it} + d^{c}, \tag{23}$$

where,

$$dc = \frac{1}{1-\beta}\left[\frac{\hat{t}K^2}{2\beta^2}\right] - \frac{1}{1-\beta}\left[\frac{K}{\beta} g + \frac{1}{2\hat{t}N} t^2 \sigma_{\varepsilon}^2 - K\overline{\theta}\right] \tag{24}$$

The cooperative policy rules can be enforced through an infinite horizon punishment mechanism, if the information structure is symmetric across countries. If both countries had exactly the same amount of information, either no knowledge at all about θ_{it} or full knowledge of

θ_{it}, we can coordinate the optimal level, and each country cannot deviate from the pre-committed policy rule, since it would entail immediate detection and due punishment in the following periods. However, in our case, where the information across countries are not symmetric, one country could pretend that its own situation looks better than it really is and could therefore choose a higher level of deficits than it is allowed. At the end of the day, we cannot see whether the previous reporting was true or not, because the private information only reveals itself with a noise term, ε_{it}. We will never know whether huge discrepancy was due to the stochastic term or due to untruthful reporting. Even though we may suspect untruthful report, there is also a verifiability problem of the projection that the suspected country made.

Given that coordination schemes are set among the countries, everyone has a positive incentive to defect from it without getting punished and will expect others to do the same. Then what will be the resulting equilibrium of this strategic behavior? Since we rule out the possibility of manipulation problems by reacting to its own shocks only, the maximization problem exactly matches the one where we non-cooperatively choose the fiscal deficit levels. The only difference is that they choose the levels, then calculate backward $\hat{\theta}_{it}(\neq \theta_{it})$ just for reporting. There is no gain from coordination in this environment, since we obtain the exact same outcome as in the non-coordination environment. Vulnerable to deception, we would be left with the low non-coordinating rules.

IV. PRECOMMITMENT EQUILIBRIUM

How can this be overcome? The first-best outcome cannot be achieved due to the informational handicap. Without strengthening the monitoring ability, it is possible to design a non-cooperative precommitment mechanism which is incentive compatible and Pareto-superior to the non-coordination rule. Although the first best cannot be achieved by applying the usual game-theoretic punishment mechanism, this paper shows that under some regularity conditions on the distribution of the uncertainty factors, there exists a precommitment mechanism which would do better than the non-coordinating outcome. Following the lines of Green and Porter(1984), a proposed plan goes as follows. All countries agree to follow a set of precommitted policy rules in the normal periods where the interest rate is below a certain specified level. However, whenever they see the interest rate goes over a certain threshold value, they agree to bear a war phase for a specified period of time. We can imagine that given the threshold level of interest rate, the countries will choose the policies to their best interest. Furthermore, the threshold value should be optimized to provide us with the maximum welfare. If it happens that the precommitted policy rules for the normal periods determined in such a way dictate lower levels of deficits and accordingly lower levels of interest rates, we can expect to find that for the normal periods, the countries will enjoy higher welfare. Since in the expansionary phase, we expect each to play the non-coordinated strategy rule (on the whole at any point in time, whether we are at the normal precommitted phase or at the war phase), we will have higher value functions than those of the non-coordination rules. However, we must remind ourselves that not just any precommitted policy rule is feasible or enforceable in this mechanism. The policy rules must be the one strategically maximizing the whole stream of the utilities taking into account the potential occurrences of both normal and expansionary periods. Since the policy scheme is strategically determined, no one has an incentive to cheat and to misrepresent the future outlook of their economy at the beginning of the period. In the following, we will seek for such a rule and will determine the conditions for the existence of such rule.

We assume that the threshold value of the interest rate is R, and the war phase is set to continue for T periods. In setting up a dynamic programming problem, we need to specify the value functions for both the normal phase, V_i^p , and for the expansionary phase, $V_i^{w,s}$ $(s=1,\dots,T)$ given the s-th stage of the war phase, as discussed above.

$$V_i^p(y_t,\theta_{it}) = \max_{\tau_{it}^p} E_{\theta_{it}}[U_{it}(\tau_t,y_t) + \beta\Pr(R_t \le R)V_i^p(y_{t+1},\theta_{i,t+1}) \\ +\beta\Pr(R_t > R)V_i^{w,1}(y_{t+1},\theta_{i,t+1})] \tag{25}$$

$$V_i^{w,s}(y_t,\theta_{it}) = \max_{\tau_{it}^{w,s}} E_{\theta_{it}}[\sum_{h=1}^{T+1-s}\beta^{h-1}U_{it}(\tau_{t+h}^{w,h},y_t) + \beta^{T+1-s}V_i^p(y_{t+T+1},\theta_{i,t+T+1})] \tag{26}$$

The optimal rules for the expansionary period, $\tau_{it}^{w,s}$, in the equation (26), can be obtained from the T decomposed equations of value functions. The results show that those optimal rules remain the same during all T stages of the war phase.

$$V_i^{w,1}(y_t,\theta_{it}) = \max_{\tau_{it}} E_{\theta_{it}}[U_{it}(\tau_t,y_t) + \beta V_i^{w,2}(y_{t+1},\theta_{i,t+1})] \tag{27}$$

$$\vdots$$

$$V_i^{w,T}(y_t,\theta_{it}) = \max_{\tau_{it}} E_{\theta_{it}}[U_{it}(\tau_t,y_t) + \beta V_i^p(y_{t+1},\theta_{i,t+1})] \tag{28}$$

Solving the above equations, we have $\tau_{it}^{w,s} = \tau_{it}^n$ for all $s = 1,\ldots,T$. This implies that during the war phase the countries will opt for the non-coordination policy rules as we have expected. The T value functions have the following forms.

$$\begin{aligned} d^{w,s} &= d^n + \beta^{T+1-s}(d^p - d^n) \\ V_{it}^{w,s} &= -\frac{K}{N\beta}y_t + \frac{K}{\beta}\theta_{it} + d^{w,s} \\ &= V_{it}^n + \beta^{T+1-s}(d^p - d^n), \end{aligned} \tag{29}$$

where d^p and d^n are, respectively, the constant terms in the value functions for the normal phase and for the non-coordinaton environment. It is clear that d^p is not smaller than d^n, since the precommitment mechanism can at least replicate the non-coordination outcomes by committing to the relevant same rules. We have to determine whether d^p can be greater than d^n. The optimal rules for the normal stage will be obtained from the following first order condition.

$$\frac{\partial E_{\theta_{it}}[U_{it}]}{\partial\tau_{it}} + \beta(1-F)\frac{\partial E_{\theta_{it}}[V_i^p]}{\partial\tau_{it}} + \beta F\frac{\partial E_{\theta_{it}}[V_i^{w,1}]}{\partial\tau_{it}}$$

$$-\beta\frac{f}{(1-t_l)NK}E_{\theta_{it}}[V_i^p - V_i^{w,1}] = 0\,, \tag{30}$$

where $F = F[\frac{1}{(1-t_l)NK}A_t - R]$ and, $f = f[\frac{1}{(1-t_l)NK}A_t - R]$ are respectively the c.d.f. and p.d.f of the error term $\frac{t}{(1-t_l)NK}\sum_{i=1}^{T}\varepsilon_{it}$. The first term measures the marginal benefit from an increase in the transfers for the current period. The second and third terms represent the marginal loss in the value function for the next period owing to the increase in the whole debt burden generated by the marginal increase in the transfer. Under the normal circumstances, without any provision of precommitment to revisionary stage, we would weigh the first against the second and third terms to determine the optimal level of transfers. However, here we have to consider an additional fourth term, which is the loss resulting from the marginal increase in the risk of entering the revisionary stage.[4] From the optimality conditions, we derive the only possible linear policy rules.

$$\tau_{it}^p = -\frac{1}{N}y_t + t\theta_{it} + \gamma^p \tag{31}$$

$$\gamma^p = -\frac{\hat{t}(N-2)K}{\beta} + \frac{2(1-t_l)K}{\beta f(x)}(\frac{1-\beta}{1-\beta^T} + \beta F(x)) - g \tag{32}$$

$$= \frac{\hat{t}NK}{\beta} - \frac{2\hat{t}K}{\beta}\left[(N-1) - \frac{(1-t_l)}{f(x)}(\frac{1-\beta}{1-\beta^T} + \beta F(x))\right] - g \tag{33}$$

$$= \gamma^n - \frac{2\hat{t}K}{\beta}\left[(N-1) - \frac{(1+t_l)}{f(x)}(\frac{1-\beta}{1-\beta^T} + \beta F(x))\right] \tag{34}$$

[4] The distribution function and density function has the unknown terms, θ_{jt}, in A_t $(= y_t + \sum\tau_{it} + Ng - t\sum\theta_{it})$. The exact expression for the first order condition should have these functions inside the expectations. However, since we know that in equilibrium under the optimal policy, θ_{jt} will be truthfully reported, it is as if we know the value. Thus the functions can be safely written outside the expectations.

where $x = \frac{1}{(1-t_l)K}(\gamma^p + g) - R$ is the gap between the actual and the threshold interest rate. Given parameters *K*, β, *T*, and *R*, constant term γ^p must satisfy the equation (34). The value function V_{it}^p is also derived given the optimal policy rules. Note that the constant terms for the value function and the transfer rules share the same last terms, the positivity of which determines whether the proposed precommitment scheme gives us better results than those of the non-coordination environment.

$$V_{it}^p = -\frac{K}{N\beta} y_t + \frac{K}{\beta}\theta_{it} + d^p \tag{35}$$

$$d^p = d^n + \frac{2(1-t_l)K^2}{\beta^2(1-\beta^T)f(x)}\left[(N-1) - \frac{(1+t_l)}{f(x)}\left(\frac{1-\beta}{1-\beta^T} + \beta F(x)\right)\right] \tag{36}$$

For some levels of R and *T*, if there exists a constant γ^p which satisfies the equation (34) and which brings $\frac{(1+t)}{f}\left(\frac{1-\beta}{1-\beta^T} + \beta F\right)$ lower than $(N-1)$, it guarantees a solution with a low level of transfers and higher value functions for the game with precommitment provision. The following proposition describes the regularity conditions on the distribution functions.

Proposition 1 *If the lower bound for* $F(x)/f(x)$ *is less than* $(N-1)/(1+t_l)$, *then there exists a precommitment provision which generates higher welfare for all countries.*

Proof) If $\frac{F(x')}{f(x')} < \frac{N-1}{1+t_l}$, then for some large T ,we can set $\delta = \frac{1}{f(x')T}$, such that $\frac{F(x')}{f(x')} = \frac{1}{f(x')T} < \frac{N-1}{1+t_l}$. Let us denote $P(x',\beta) = \frac{1}{f(x')}$

$(\frac{1-\beta}{1-\beta^T}+\beta F(x'))$. Then, $\lim_{\beta->1} P(x',\beta)=\frac{F(x')}{f(x')}+\frac{1}{Tf(x')T}$. For sufficiently large T and for $\overline{\beta}$ close to 1, we have $P(x',\beta)=\frac{N-1}{1+t_l}$. We conclude that for all $\beta\geq\overline{\beta}$, we have $P(x',\beta)<\frac{N-1}{1+t_l}$. Now for such x', we derive the policy rule according to the equation (32), $\gamma(x')=-\frac{\hat{t}(N-2)K}{\beta}+\frac{2(1-t_l)K}{\beta f(x')}(\frac{1-\beta}{1-\beta^T}+\beta F(x'))-g$ and set R to be $R(x')=\frac{1}{(1+t_l)K}(\gamma^p(x')+g)-x'$. Then for $\beta\geq\overline{\beta}$, we have T and $R(x')$ such that $\frac{1}{f(x')}(\frac{1-\beta}{1-\beta^T}+\beta F(x'))<\frac{N-1}{1+t_l}$. This implies that the term inside of the bracket in equation (36) is positive, and thus $d_p-d_n>0$ Q.E.D

When we consider the class of symmetric unimodal distributions, the condition in the proposition implies that the distribution of the shock should be concentrated toward the center to some extent. The implication is that when the probability is distributed over the wide range of region rather than clustered in the center, there are two effects that prevent the coordination. First, suppose we set the threshold value at a low level. Then we would expect the occurence of violations to be frequent, even if we follow some precommitted cooperative rules that dictate lower levels of deficits. Since most of the time we will be in the reversionary stage, the countries could well benefit enough from a one-time deviation when they are at the normal precommitted stage. Second, suppose to the contrary we set the threshold interest rate at a high level. The range of freedom is high, and even a huge deviation from the precommitted level will not bring about a reversion, and thus, will not be detected. However, when the conditions are met, there will be a threshold value for interest rates which would bring about the equilibrium budget deficit levels to be lower than the ones in non-coordination. It will prevent the two types of deviation incentives discussed above, since here the loss from deviation outweighs the benefit. In the following, we obtain the result that welfare increasing precommitment coordination exists when the shocks have normal distributions and the variances are not too large.

Corollary 1 When ε *has a normal distribution, and the variance is less than some value* $\overline{\sigma}$ *, there exists a welfare improving incentive compatible precommitment provision* (*R, T*).

Proof) We know when $x = 0, \dfrac{F(0)}{f(0)} = \dfrac{\sqrt{2\pi\sigma}}{2}$, then for sufficiently small σ, we have $\dfrac{F(0)}{f(0)} = \dfrac{\sqrt{2\pi\sigma}}{2} < \dfrac{N-1}{1+t_l}$. There exist some *x*(= 0) which satisfies the condition in Proposition 1, thus by the proposition we have for some $\overline{\beta}$, that for all $\beta \geq \overline{\beta}$, $d_p - d_n > 0$. Q.E.D

Since the random variable we have in mind is $\varepsilon = \dfrac{t}{(1-t_l)NK}\sum_{i=1}^{T}\varepsilon_{it}$ and ε_{it} is assumed to be identical and independently distributed with finite variance σ_ε, by the central limit theorem, we obtain the following asymptotic distribution of ε .

$$\varepsilon \overset{A}{\sim} N(0, \frac{t^2\sigma_\varepsilon^2}{(1-t_l)^2K^2N})$$

As the number of participating countries grows, the distribution will asymptotically approach the normal distribution and the variance will be gradually reduced to fulfill the condition in the corollary at some point. This implies that the proposed system has a better chance to work when the international capital market is globalized and when the potential losses from noncoordination are greater.

V. COMPARATIVE STATICS

We have seen that even when the information across agents are asymmetric, we have a better way of living than just to continue to behave non-cooperatively. Given the circumstances, the monitoring cost is minimal, and we only need to have the precommitment stage to set the threshold rate and follow the rules closely watching the movements of the world interest rate.

Granted that the regularity conditions are met, we inquire what level of interest rate will provide us with the welfare maximizing mechanism and what will be the corresponding level of budget deficits for each country. Equation(36) gives us the level of the value function of each country. It depends on the threshold value R and the duration of the reversionary stage T. Once they are set at the appropriate values, we can determine γ^p and d^p. First we set T at a given level. Now both equations solely depend on the variable x, which we defined before as the gap between the expected level of interest rate when following the proposed policy rule and the threshold value, $x = \frac{1}{(1+t_l)K}(\gamma^p + g) - R$. Since $F(x)$ is the probability of triggering reversionary phase, we ask how much higher should we set the threshold value than the expected rate of returns. We choose to maximize the value function V^p with respect x. This is equivalent to maximizing d^p with respect to x, and thus obtained optimal level of x is x^*.

$$x^* \in \arg\max_{x\in\Omega} d^p(x),$$

where Ω is the feasibility set in which the regularity condition holds. Given x^*, we obtain the optimal $\gamma^p(x^*)$ from Equation (34). The optimal threshold interest rate is then determined as follows:

$$R(x^*) = \frac{1}{(1+t_l)K}(\gamma^p(x^*) + g - x^*)$$

Now to characterize the comparative statics of equilibrium outcomes, we assume that the optimal x^* has an interior solution which maximizes the value function. Then this global maximum must satisfy the following first order necessary condition.

$$\frac{\partial d^p(x^*)}{\partial x} = \frac{\partial d^p}{\partial f}\frac{\partial f(x^*)}{\partial x} + \frac{\partial d^p}{\partial F}\frac{\partial F(x^*)}{\partial x} = 0 \tag{37}$$

$$A\left[-(1-t_l)-\frac{f'(x^*)}{f(x^*)}\left[\hat{t}(N-1)-\frac{2(1-t_l)}{f(x^*)}\left(\frac{1-\beta}{1-\beta^T}+\beta F(x^*)\right)\right]\right]=0 \quad (38)$$

where $A=\dfrac{2(1-t_l)K^2}{\hat{t}\beta^2(1-\beta^T)f}$.

Since the non-coordination budget deficit is higher than the coordination level and countries benefit by setting their budget deficit at a higher level, it would be reasonable to set the trigger level of interest rate at somewhat higher than the expected interest rate to partly allow some room for the stochastic term and, at the same time, to guard against the deviations. This means that the optimal threshold value $R(x^*)$ is set above $E_{\theta_{it}}[R(x^*)]$, the expected interest rate in the normal period given that everyone chooses precommitment budget deficits.

What is the level of γ^p relative to coordination and non-coordination equilibrium? In symmetric unimodal distributions, the p.d.f, is non-decreasing at the values x lower than the mean. As we have assumed that the error terms take zero means, negative x^* implies that $f'(x^*)$ to be positive. When $f'(x^*)$ is positive, we see from the first order condition equation (38) that the term inside the bracket must be negative. Thus,

$$\hat{t}(N-1)-\frac{2(1-t_l)}{f(x^*)}\left(\frac{1-\beta}{1-\beta^T}+\beta F(x^*)\right)<0 \quad (39)$$

Multiplying K/β on both sides, we have:

$$\frac{\hat{t}(N-1)K}{\beta}<\frac{2(1-t_l)K}{\beta f(x^*)}\left(\frac{1-\beta}{1-\beta^T}+\beta F(x^*)\right) \quad (40)$$

Given that the regularity condition described in Proposition 1 is satified, we have also:

$$(N-1)-\frac{(1-t_l)}{f(x^*)}\left(\frac{1-\beta}{1-\beta^T}+\beta F(x^*)\right)>0 \quad (41)$$

Multiplying $2\hat{t}K/\beta$ on both sides, we have:

$$\frac{2\hat{t}(N-1)K}{\beta} > \frac{2(1-t_l)K}{\beta f(x^*)}\left(\frac{1-\beta}{1-\beta^T}+\beta F(x^*)\right) \tag{42}$$

With equations (40) and (42), equation (32) gives us the range of γ^p. As expected, we find that γ^p is less than the non-coordination level and greater than the one of pure coordination.

$$\frac{\hat{t}(N-1)K}{\beta} < \gamma^p + \frac{\hat{t}(N-2)K}{\beta} + g < \frac{2\hat{t}(N-1)K}{\beta} \tag{43}$$

$$\frac{\hat{t}K}{\beta} < \gamma^p + g < \frac{\hat{t}NK}{\beta} \tag{44}$$

$$\gamma^c < \gamma^p < \gamma^n \tag{45}$$

Variance (σ) What is the welfare implication when the uncertainties are larger (i.e, when the error terms are more widely distributed with larger variance? Do we gain more when we have higher variances by switching to the precommitment mechanism from non-coordination?). To study the effect, we first assume that the errors are normally distributed. We maintain the assumptions in the Corollary 1 to hold. Since cdf is $F(x(\sigma),\sigma)$ and pdf is $f(x(\sigma),\sigma)$, the variance will work through two channels to influence the value function. We see that the change in the variance will affect the choice of x and will bring about the change in the optimal level of fiscal deficit, γ^p, and the threshold interest rate, R^p. Moreover, we can think of the changes in the value functions due to variance directly affecting the cdf and pdf of the distribution. First, let $\hat{d} = d^p - d^n$ and determine the change in the gap when the variance changes. Note that $\frac{\partial \hat{d}}{\partial f} = \frac{\partial d^p}{\partial f}$ and $\frac{\partial \hat{d}}{\partial F} = \frac{\partial d^p}{\partial F}$. Applying the envelope theorem or the first order condition in equation (37), the first effect will be null. We only need to consider the direct effects of the cdf and pdf.

$$\frac{\partial \hat{d}}{\partial \sigma} = [\frac{\partial d^p}{\partial f}\frac{\partial f(x^*)}{\partial x} + \frac{\partial d^p}{\partial F}\frac{\partial F(x^*)}{\partial x}]\frac{\partial x}{\partial \sigma} + [\frac{\partial \hat{d}}{\partial f}\frac{\partial f(x^*)}{\partial \sigma} + \frac{\partial \hat{d}}{\partial F}\frac{\partial F(x^*)}{\partial \sigma}]$$

$$= \frac{\partial \hat{d}}{\partial f}\frac{\partial f(x^*)}{\partial \sigma} + \frac{\partial \hat{d}}{\partial F}\frac{\partial F(x^*)}{\partial \sigma} = \frac{\partial \hat{d}}{\partial F}\frac{\partial F_1}{f_1} f_2 + \frac{\partial \hat{d}}{\partial F} F_2$$

$$= \frac{\partial \hat{d}}{\partial F} f_2 (\frac{F_2}{f_2} - \frac{F_1}{f_1}) = \frac{\partial d^p}{\partial F} f_2 (\frac{F_2}{f_2} - \frac{F_1}{f_1}) \tag{46}$$

$$= -\frac{\partial d^p}{\partial F}\frac{f(x^*)\sigma}{x^*} \tag{47}$$

Since $\frac{\partial d^p}{\partial F} = \frac{-2t^2}{\hat{t}\beta(1-\beta^T)N^2 f^2} < 0$, if the optimal x is negative, we have $\frac{\partial \hat{d}}{\partial \sigma} < 0$. The benefit from switching to the alternative system declines as the uncertainty factor becomes more significant. When we expect the economy to be highly volatile, there are two effects on the value functions to consider. If the threshold value is set to allow for the volatility, each country has more room in selecting the level of fiscal deficits. To prevent misrepresentation and give an incentive to truthfully represent and support the system, the optimal level of fiscal deficits in the normal stage must to be higher than before. If the optimal threshold happens to be near the previous equilibrium, we can expect more reversions in the equilibrium path due to the larger variance of the error terms.

Number of Countries (N) As the number of countries with open capital markets increases, we expect the level of welfare for each country to decrease in the non-coordination environment, since more externality is expected. As the first best policy remains the same regardless of the number of countries, there is greater room for the alternative system to gain. Furthermore, as we have seen above, the variance of the stochastic term will gradually shrink and the volatility of the world rate of returns will be reduced. This is another source of gains from choosing the proposed system.

$$\frac{\partial \hat{d}}{\partial N} = [\frac{\partial \hat{d}}{\partial f}\frac{\partial f(x^*)}{\partial x} + \frac{\partial \hat{d}}{\partial F}\frac{\partial F(x^*)}{\partial x}]\frac{\partial x}{\partial N}$$

$$+ [\frac{\partial \hat{d}}{\partial f}\frac{\partial f(x^*)}{\partial \sigma} + \frac{\partial \hat{d}}{\partial F}\frac{\partial F(x^*)}{\partial \sigma}]\frac{\partial \sigma}{\partial N} + \frac{\partial \hat{d}}{\partial N} \tag{48}$$

$$= [\frac{\partial \hat{d}}{\partial f}\frac{\partial f(x^*)}{\partial \sigma} + \frac{\partial \hat{d}}{\partial F}\frac{\partial F(x^*)}{\partial \sigma}]\frac{\partial \sigma}{\partial N} + \frac{\partial \hat{d}}{\partial N}$$

$$= \frac{\partial d^p}{\partial F} f_2[\frac{F_2}{f_2} + \frac{F_1}{f_1}]\frac{\partial \sigma}{\partial N} + \frac{2(1-t_l)K^2}{\beta^2(1-\beta^T)f}$$

$$= \frac{\partial \hat{d}}{\partial \sigma}(-\frac{\sigma_\varepsilon}{2N}) + \frac{2(1-t_l)K^2}{\beta^2(1-\beta^T)f} > 0 \tag{49}$$

The first term is the effect of the increase in the number of countries on the welfare gain through the channel of the reduction in the variance. As discussed above, $\frac{\partial \hat{d}}{\partial \sigma}$ is negative, thus giving us the positive value for the whole. The second term describes the magnitude of the drop in the welfare due to the rise in externality as N becomes larger, when we do not adopt the new system. The exact amount is saved when we decide to choose the proposed system. Whether the proposed system will approach the first-best, when the number of countries increase, is a valid and interesting question. However, the result is ambiguous and depends on the distributional assumptions.

VI. CONCLUSION

We have seen the existence of inefficiency due to the noncoordination of fiscal policies among countries with open capital markets. This issue has been brought out to emphasize the need for the coordination of all fiscal policies, not only the well-debated monetary policies. The proposed solution has been simply to discuss and coordinate the socially optimal policy, and enforce it using the punishment mechanism. Although the previous literature has contributed to raise the issue and alert the crowd about the need for the coordination, it has abstracted from some important features of the world, uncertainty and information.

This paper tries to point out the inherent problems in enforcing the first-best outcome in the world with uncertainties and asymmetries of information. Without the full monitoring capabilities or the verifiability of the projections, we cannot achieve the first best.

As an alternative, the paper proposes a precommitment system with minimal informational requirements, which give us welfare improvement.[5] The attractiveness is the simplicity and the minimality of the information that is necessary to enforce this outcome. The gains from choosing the system increase as the international market gets more and more globalized and drops when the economy becomes more volatile. Moreover, when a new country enters this integrated world, the best policy for the entrant is to form the same set of policy rules as the other countries.

The feasibility of choosing the fiscal policy with such a flexibility can may be questionable. However, we have seen some changes in the trend of fiscal deficits with marked phases in the past. A completely flexible operation of fiscal deficit policy would not be politically feasible and is also unrealistic. Nevertheless, the trend in terms of phases or periods could possibly be determined by the government, if they take the need for coordination seriously. The internationalization of capital markets puts us under pressure to look for the behaviors of others in determining the policy in our best interest. The point is that the need for coordination is severe. The best choice would be to accurately project the prospects of all the economies and coordinate policies accordingly. However, if we are burdened with informational handicap, setting a specific rule and observing the rule is more welfare improving than arbitrary coordination and negotiation, which can be obscured by the deficiency of information.

[5] As a potential extension of this study, it is conceivable to apply this theoretical framework to other issues such as patent policy and copyright violations, or capital market policy and manipulative activities.

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