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Decentralized International Risk Sharing and Governmental Moral Hazard

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Abstract

This paper studies the issue of moral hazard in the presence of decentralized international risk sharing. In the model presented, risk sharing is achieved through macro markets (markets in which claims to the GDP of a country can be traded). Moral hazard arises for the following reason: if foreigners hold claims to domestic GDP due to risk sharing motives, the country will not receive the full benefit from its production anymore. This can motivate for example a tax on investment (which reduces production) or simply result in reduced governmental effort to increase productivity. We show in a two-country general equilibrium framework that the moral hazard problem does not lead to a reduction in the risk sharing (households hold half of world output). This results ultimately in a 100% tax on investment and creates a huge distortion. We conclude that unregulated macro markets pose a serious threat to world welfare. The analysis also raises concern about the desirability of decentralized risk sharing in general, in particular risk sharing through international trade of equity.

Keywords: international risk sharing, macro markets, moral hazard

JEL Codes: F30, G11

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1 Introduction

Do governments face changed incentives when domestic agents have international risk-sharing agreements? How would this feedback into markets for risk sharing? And, what are the consequences for the desirability of such risk sharing agreements? These questions are of particular interest against the background of an increasing international asset diversification and the possible introduction of macro markets. In these markets, as originally proposed by Shiller (1993), assets are traded of which the dividends are linked to macroeconomic indexes such as for example the GDP of a country. Individuals and firms can use these assets in order to insure the part of their income which is affected by aggregate factors. There is a wide range of studies on the potential gains from such risk-sharing,[1] some estimated being large and in the range of up to 3.5% of permanent tradeables consumption for a 50 years horizon.[2]

The purpose of this paper is to examine the above raised questions in a world in which international risk sharing can be achieved through such macro markets. The basic idea why the government plays a role is the following: if individuals insure national output through macro markets then the government has an incentive to carry out policies at the cost of reducing output (moral hazard).[3] Due to the complexity of these policies, the government cannot credibly commit. Rational individuals take this into account and may adjust their risk-sharing activities accordingly.

The issue of moral hazard on the side of the government caused by macro markets has to the knowledge of the author not yet been treated in the literature. There is, however, a large literature on moral hazard and hidden information problems caused by international risk sharing in general. The imperfections arise there (among others) because states of nature cannot be observed by all parties and thus a country or an individual is tempted to claim that it was hit by an adverse shock even if it is not (e.g., Green[1987] and Taub[1990]) or because effort (or analogously investment) can change payoffs or the likelihood of the states (Greenwood and Williamson [1989]

[1] See for instance Lucas (1987), Cole and Obstfeld (1991), van Wincoop (1994) and Tesar (1995).

[2] van Wincoop (1999)

[3] Although the government is not in the typical moral hazard situation (it is neither part of a contract nor the agent who can actually change the pay-off of the contract), it will be in the following referred to moral hazard since the arising incentives are similar.

and Atkeson[1991]). If this is the case and for example investment is private information, there is an incentive to underinvest since with risk-sharing the agents do not fully participate in the marginal benefit of their investment. This is in principal the same source of moral hazard as in the model here. For the purpose of the paper the literature can be divided in two classes: models in which the risk sharing is obtained via central agreements (usually between governments) and models in which individuals enter risk-sharing agreements (e.g., through international borrowing and lending).[4] In the former class, the moral hazard arises on the side of the government which can for example reduce its effort to raise output; in the latter where risk sharing is achieved by individuals, typically the individuals itself are subject to opportunism. What these models find is that the given imperfections reduce the potential gains from risk sharing or that risk sharing does not take place at all. All in all, risk sharing in this studies does not lead to a welfare reduction (with homogenous agents). The case of macro markets falls in the latter class: risk sharing is obtained by individuals. However, in contrast to the above studies the government is subject to moral hazard problems because it can directly or indirectly influence the payoff of the risk sharing assets. In principal, such a setting also applies to the analysis of international borrowing and lending or foreign direct investment between private agents (for a survey see Eaton and Fernandez[1995]). In these models, however, the risk sharing is obtained by contracting on individuals assets (e.g., a firms equity) in contrast to macro markets, where aggregate risks are shared. Again, these models find welfare improvements or break down of the markets. The novelty of the analysis of this paper is thus that it examines international risk sharing in aggregate risks in combination with the fact that the risk sharing is obtained on an individual basis. It will be shown that this causes important intranational externalities which do not arise in the other models and leads to adverse welfare effects.[5]

[4] The distinction itself is not particularly relevant for analysis: Green (1990) and Taub (1990) can be put into the former class, Atkeson (1991) and Greenwood and Williamson (1989) into the latter. See Obstfeld and Rogoff (1996), chapter 6 for further references. There is also large literature on risk sharing within federal constitutions which poses similar problems. See for example Bordignon, Manasse and Tabellini (1996) and Persson and Tabellini (1996). The latter provides a rich positive analysis of moral hazard problems.

[5] The setup can be viewed as an extended principal-agent-relationship, where the foreign insurer is the principal and the domestic household is the agent. Additionally, domestic agents have their own agent (the government) who has no self-interest (government is benevolent).

There are further studies explicitly addressing time inconsistency problems in connection with international risk sharing, i.e., in the setting of foreign investment and international lending (Eaton and Fernandez[1995]). Time inconsistency can arise because the government, after investment has taken place, taxes the foreign capital. Foreign investors anticipate that and depending on whether it is possible to solve the time inconsistency problem risk sharing takes place or breaks down. Throughout the paper it is assumed that the government cannot commit at all. The reason is that for the type of moral hazard considered here it is difficult for the government to commit to a certain behavior, simply because potential government actions are so rich that they cannot be fully observed by other parties. Hence the scope for reputational arguments is limited and the time inconsistency problem cannot be resolved. Somewhat surprisingly, it turns out that this does not affect the amount of risk sharing.

Generally, the scope for international risk sharing may be limited through the problem of the enforceability of the underlying contracts. These issues have been dealt with extensively in the literature (for references for the case of sovereign default, see Obstfeld and Rogoff[1996], chapters 6.1. and 6.2.). It will be argued below that settlement for the here considered risk sharing contracts can be constructed such that enforceability problems do not arise. The analysis thus assumes the enforceability of risk sharing contracts conditioning on aggregate output.

This paper adds moreover to the literature on asset pricing and moral hazard in the presence of incomplete markets. There the question is posed whether the existence of assets which are subject to moral hazard (for example if the owner of a firm issues shares) leads to constrained pareto-optimal allocations.[6] A number of studies find that this is true if asset trades are observable.[7] The setup differs from the analysis here in that there the pay-off from the asset is solely under influence of the individual which engages in the market; in the setup discussed here a third party (the government) can indirectly change the pay-offs from the assets by changing the economic environment of the households. It will be of interest whether the results carry

[6] Constraint pareto-optimality refers there to the fact that the allocation is efficient given the imperfections being present: the moral hazard and the incompleteness of the markets.

[7] See Kahn (1990), Shorish and Spear (1996), Kocherlakota (1998) and Magill and Quinzii (1998).

over.[8]

The paper addresses the issue by studying the general equilibrium of a simple two-country model where production is subject to country specific shocks. There exists a market in which a swap in the countries' output can be traded (the macro market). As an example for policies which affect output, the government can levy taxes on investment. By doing so, the government can increase current consumption but reduces future output. The latter effect is partly compensated through increased payments from the risk sharing assets.

The solution to the model reveals that the government's decision regarding the tax does not affect the quantities traded in the swap at all. The intuition for that is that households price any expected taxation into the swap, hence expected pay-offs are zero but the swap still has its value for the individuals in terms of risk-sharing. Thus in equilibrium, the classical result that households hold equal shares of world output (as they would do without government inference) still holds. As a consequence, the government imposes a capital tax (100%) since it wants to internalize externalities and the resulting distortion leads to a welfare reduction. The externalities arise because additional investment of a household increases the countries' output and thus reduces payments from the swap for all domestic households (if the countries were populated by a single household, they would choose not to take any positions in the swap). The 100% taxation stems from the fact that with half of the output swapped, only half of every additional unit of production remains in the country. Thus, in order to make investment beneficial for the country, marginal productivity has to be twice as high as in the case without risk sharing agreements. A capital tax of 100% exactly ensures this condition. Since the optimal taxation only depends on the share of output swapped, no specific assumptions about utility and production functions are needed to obtain the results.

To the knowledge of the author, the result of a welfare reduction due to a new asset is new to the literature on international risk sharing. The result arises because of the separation of the individual who actually enters the risk sharing agreements from the person who is subject to moral hazard

[8]There is also a branch of literature emphasizing the role of the government in incomplete markets. However, the scope for government activity there is very different: government intervention through taxation can be justified in that it can improve efficiency through equalizing marginal rates of substitution (Newbery and Stiglitz[1982] and Stiglitz[1982]).

combined with the fact aggregate risk sharing instruments are traded. The findings challenge further results from the incomplete market literature (i.e., Magill and Quinzii [1998]): if there is a body that can influence the pay-offs of the assets (e.g., a government through capital taxation), constrained pareto-optimal allocations may not be achieved. This is particularly interesting, since these studies aim at examining the equity premium puzzle and the home bias puzzle (Kahn[1988], Kocherlakota[1998]). Whether this can potentially have consequences for these puzzles is left for future research.

How robust are the results? The papers considers some modifications to the original setup and finds that the high capital tax is not sensitive to the changes. Moreover, capital taxation is only one of the means of a government reacting to the risk sharing, similar results would arise for example for a labor tax. Further, countries may be affected differentially, thus there may be the case of some countries gaining (while world welfare is reduced). Given this finding and recognizing that there is an incentive for private organizations to introduce the macro markets, the paper turns to the analysis of policy measures which aim at avoiding the detrimental effects of the markets. Such measures are the extension of the terms of the swap-contract in order to change the incentives for the government and the addition of more risk sharing assets to the economy. Alternatively, the payments from the risk sharing assets could be made contingent on an evaluation of an international institution which watches the government. It turns out that the issues are fairly complicated and no readily available advice can be given, the analysis calls for more research into that area. Finally, the discussion suggests that a regulation of the trade in the markets is also not a straightforward issue since in order to be effective it requires international coordination.

The remainder of the paper is organized as follows. Section 2 outlines the model and describes its solution. Section 3 considers then some extensions to the model. In section 4 implications of the results for policy are discussed. The final section concludes.

2 The Model

2.1 A World Economy With An International Macro Market

The paper concentrates on the simplest setup in which there is international risk sharing due to asset markets and a government which can change households incentives. Specifically, the general equilibrium of a two country, two period model where each country (A, B) is populated by a continuum of identical households (with measure 1) will be studied.[9] Each household has an initial endowment y_0 of a single perishable good. Countries are identical. The endowment y_0 can be consumed in the first period (c_1) or invested: either in an international bond market (b) or in capital for home production (k). Investment in bonds yields a risk-free return of $(1 + r)$ in the second period. Returns to home production are subject to shocks, which are country specific. Labor is supplied inelastically by the households. More precisely, an investment k_i of household i in country A results in a production of $f(k_i^A)(1+\varepsilon^A)$, analogous for country B in $f(k_i^B)(1 + \varepsilon^B)$. The shocks ε^A and ε^B are normally distributed with variance σ^2 and zero mean; they are assumed to be uncorrelated across the countries.[10] The households maximize their expected two-period utility, which is assumed to be time separable.

There exists an international macro market where households can trade a future in period 1. This future (or swap) is a claim to the difference of the outputs in the two countries $f^B(1 + \varepsilon^B) - f^A(1 + \varepsilon^A)$ in period 2, where f is the average output $\int_{i\in[0..1]} f(k_i)dk_i$. The maturity price of the swap is p. Settlement takes place in the second period after uncertainty about output is resolved. The motivation for the introduction of the swap is that households can use it in order to diversify and thus reduce the volatility of their second period consumption by shorting own output and investing the receipts into claims to foreign output.[11]

The governments in the both countries maximize their re-election prob-

[9] The model of the asset market is a simplified version of Shiller and Athanasoulis (1997).

[10] None of the results below will change unless the shocks are not perfectly correlated. Increases in correlation will just mean a reduction in the potential gains from risk-sharing.

[11] Since their is only one risk sharing asset available, households are forced while buying claims to the other countries output to go short in their own countries' output. This assumption will be later relaxed in section 3.

abilities, which are increasing in the utility of the domestic households. The policy instrument of the government is a tax t on (domestic) capital. Tax receipts are given back to the households in the same period by means of a lump sum payment T (in absence of international risk-sharing there is of course no motive for taxation).

The timing of the actions in the model can be summarized as follows: in period 1 households take their positions in the future q (subperiod 1), then the government announces the tax rate t (subperiod 2). Based on the tax rate, households then make their consumption (c_1) and investment decisions (b and k) (subperiod 3). In the second period, the uncertainty is resolved, the futures are settled and the households consume their resulting budget (c_2).

The budget equations for household i in country A (analogous for country B) for period 1 and 2 are (choice variables are indexed by i):

$$c_{i,1}^A + b_i^A + (1 + t^A)k_i^A = y_0 + T^A \tag{1}$$

$$c_{i,2}^A = b_i^A(1 + r) + f(k_i^A)(1 + \varepsilon^A) + q_i^A[f^B(1 + \varepsilon^B) - f^A(1 + \varepsilon^A) - p] \tag{2}$$

The government balances its budget, thus $T^A = t^A k^A$ and $T^B = t^B k^B$. Market clearing for the bond market requires $b^A = -b^B$ and for the swap $q^A = -q^B$ (k, b and q refer to the country wide average of the respective individual variables k_i, b_i, q_i).

2.2 Optimal Consumption and Investment Plans

The model will be solved in reverse chronological order. In subperiod 3, households in country A maximize their expected intertemporal utility

$$U(c_{i,1}^A, c_{i,2}^A) = u(c_{i,1}^A) + \beta E_1[u(c_{i,2}^A)] \tag{3}$$

(where β is the discount factor and $E_1[\cdot]$ the expectation operator conditional on information in period 1) subject to their swap positions q_i^A, the tax rate t^A and the budget equations (1) and (2). Optimal choice of bonds b_i^A and capital investment k_i^A then requires

$$\frac{\partial U(c_{i,1}^A, c_{i,2}^A)}{\partial b_i^A} = 0! \Rightarrow u'(c_{i,1}^A) = \beta(1+r)E_1[u'(c_{i,2}^A)] \quad (4)$$

$$\frac{\partial U(c_{i,1}^A, c_{i,2}^A)}{\partial k_i^A} = 0! \Rightarrow (1+t_A)u'(c_{i,1}^A) = \beta E_1[u'(c_{i,2}^A)f'(k_A)(1+\varepsilon^A)] \quad (5)$$

Using Stein's lemma, the right side of (5) can be manipulated to[12]

$$(1+t_A)u'(c_{i,1}^A) = \beta f'(k_i^A)[E_1[u'(c_{i,2}^A)] + \sigma^2 E_1[u''(c_{i,2}^A)](f(k_i^A) - q_i^A f^A)] \quad (6)$$

The last term in equation (6) appears since investment in capital is risky and thus requires a higher expected return.

2.3 Capital Taxation

In subperiod 2, the government sets the tax rate on capital such as to maximize the welfare of the country. The scope for government activity arises because of the negative externalities of investment between domestic households: a higher investment in capital of a household increases the expected output of the country which in turn lowers the payments of all households of the country from the swap contracts (if households are short in their output). The government in country A thus maximizes utility by internalizing the externalities given the average swap positions q^A (the latter determining the size of the externality). Since households are homogenous, they all face the same optimality conditions and their decisions are thus identical in equilibrium (individual values are interchangeable with average values). Hence, the government simply maximizes the expected utility of an arbitrary household. To determine the optimal taxation of the government in country A, consider the country consisting of one household only. Externalities are obviously absent in this case and the second period budget equation (2) (without taxation) becomes

$$c_{i,2}^A = b_i^A(1+r) + f(k_i^A)(1+\varepsilon^A) + q_i^A[f^B(1+\varepsilon^B) - f(k_i^A)(1+\varepsilon^A) - p] \quad (7)$$

[12] Stein's lemma states that if two random variables X and Y are jointly normal distributed and $E[Y] = 0$ and $f(\cdot)$ is a continuous function then $E[f(X)Y] = E[f'(X)]Cov(X,Y)$. Thus, $E_1[u'(c_{i,2}^A)(1+\varepsilon^A)] = E_1[u'(c_{i,2}^A)] + E_1[u''(c_{i,2}^A)Cov(c_{i,2}^A, \varepsilon^A)] = E_1[u'(c_{i,2}^A)] + \sigma^2 E_1[u''(c_{i,2}^A)](f(k_i^A) - qf^A))$.

with the only difference to equation (2) being that the household can now influence the pay-off from the swap due to his own investment decision. The corresponding first order condition is then:

$$u'(c_{i,1}^A) = \beta(1 - q_i^A)f'(k_i^A)E_1[u'(c_{i,2}^A)] + \sigma^2 E_1[u''(c_{i,2}^A)](1 - q_i^A)f(k_i^A)) \quad (8)$$

If the government sets the tax-rate to $1+t^A = 1/(1-q_i^A)$ then equation (6) is identical to (8), that is the households face the same optimality condition as in the case with internalized externalities (one household). Since $q_i^A = q^A$ in equilibrium, the optimal tax rate in country A is

$$t^A = q^A/(1 - q^A) \quad (9)$$

and depends only on q^A. As mentioned above, in a world without contracts ($q^A = 0$), the government would set the tax rate to zero reflecting the absence of externalities. Furthermore, the optimal tax-rate rises with the share of national output insured by contracts (q^A) due to an increase in the externalities between the households (identical analysis applies to country B).

2.4 Equilibrium in the Swap-Market

In the beginning of the first period (subperiod 1), the households take positions in the macro market. In equilibrium they anticipate the tax rate t^A. Budget equation (1) then becomes

$$y_0 + \frac{q^A}{1 - q^A}k^A = c_{i,1}^A + b_i^A + \frac{1}{1 - q^A}k_i^A \quad (10)$$

while second period budget equation (2) does not change. The optimal choice of the position in the swap hence requires

$$\frac{\partial U(c_{i,1}^A, c_{i,2}^A)}{\partial q_i^A} = 0! \Rightarrow E_1[u'(c_{i,2}^A)(f^B(1 + \varepsilon^B) - f^A(1 + \varepsilon^A) - p)] = 0 \quad (11)$$

Making again use of Stein's lemma, this can be written as

$$E_1[u'(c^A_{i,2})](f^B - f^A - p) + \sigma^2 E_1[u''(c^A_{i,2})](q^A_i((f^B)^2 + (f^A)^2) - f^A f(k^A_i)) = 0 \quad (12)$$

2.5 Properties of the Equilibrium

Having stated the optimality conditions of all agents, it will be now proceeded to obtain a solution for the equilibrium swap positions. Setting $f(k^A_i) = f^A$ in (12) and dividing (12) by $E_1[u'(c^A_{i,2})]$ one obtains

$$f^B - f^A - p - \sigma^2 \gamma(c^A_{i,2})(q^A_i((f^B)^2 + (f^A)^2) - (f^A)^2) = 0 \quad (13)$$

where $\gamma(c^A_{i,2}) = -E_1[u''(c^A_{i,2})]/E_1[u'(c^A_{i,2})]$ is the coefficient of absolute risk-aversion. Solving equation (13) for p and setting $q^A_i = q^A$ and $c^A_{i,2} = c^A_2$ yields

$$p = f^B - f^A + \sigma^2 \gamma(c^A_2)((f^A)^2 - q^A((f^A)^2 + (f^B)^2)) \quad (14)$$

Thus the price of the swap is the difference between the expected output in the both countries $(f^B - f^A)$ plus a term which arises because the contract can be used to diversify and thus reduces risk for households in A. For country B the corresponding equation is

$$p = f^B - f^A + \sigma^2 \gamma(c^B_2)(-(f^B)^2 - q^B((f^A)^2 + (f^B)^2)) \quad (15)$$

Substituting in (14) and (15) for the price p and using the market clearing condition $q^A = -q^B$ yields an equation for the number of swap positions q

$$q = q^A = -q^B = \frac{\gamma(c^A_2)(f^A)^2 + \gamma(c^B_2)(f^B)^2}{[\gamma(c^A_2) + \gamma(c^B_2)][(f^A)^2 + (f^B)^2]} \quad (16)$$

The right side of (16) is positive, thus countries diversify by taking short positions in their own output (and thus long positions in the output of the other country). Generally, q is higher than $1/2$ if the country with the higher expected output also has the higher absolute risk aversion and lower than $1/2$ if the country with higher output has a lower degree of absolute risk aversion.[13] To simplify the further analysis it is assumed that the countries

[13] Proof: see appendix A.

have constant absolute risk aversion $\gamma(c_2^A) = \gamma(c_2^B) = \gamma$.[14] Equation (16) then simplifies to

$$q = q^A = -q^B = 1/2 \tag{17}$$

Thus, the amount of output insured in equilibrium is independent of the government actions, that is the tax rate. From (14) one obtains an equation for the maturity price

$$p = f^B - f^A + \frac{\sigma^2\gamma((f^A)^2 - (f^B)^2)}{2} \tag{18}$$

The contract has a premium above the expected output differences $f^B - f^A$ if and only if $f^A > f^B$.[15] Next it will be solved for the equilibrium tax rate, the ratio of output between the countries and the price of the contract. Equation (9) shows that for $q = 1/2$

$$t^A = t^B = 1 \tag{19}$$

thus investment is penalized by a capital tax of 100%. Further, the intertemporal ratio of marginal utilities of consumption is equalized between the countries through the bond market (this can be seen by writing equation (4) also for country B):

$$u'(c_1^A)/E_1[u'(c_2^A)] = \beta(1+r) = u'(c_1^B)/E_1[u'(c_2^B)] \tag{20}$$

Rearranging the condition for optimal investment in capital (5) for both countries and dropping the subscripts i one gets a alternative expressions for the ratio of the intertemporal marginal utilities

$$u'(c_1^A)/E_1[u'(c_2^A)] = \frac{\beta f'(k^A)}{1+t^A}[1 - \sigma^2\gamma(1-q^A)f(k^A)] \tag{21}$$

[14] For the general case of risk-aversion, the symmetric solution as outlined below still exists, but may not be unique. To check the existence of the symmetric equilibrium, note that $\gamma(c_2^A)$ has then to equal $\gamma(c_2^B)$ which will result in $q = 1/2$ (equation (16)).

[15] The intuition for that is that when $f^A > f^B$ the households of country A have potentially more output to insure than the households in B. This will drive the maturity price up.

$$u'(c_1^B)/E_1[u'(c_2^B)] = \frac{\beta f'(k^B)}{1+t^B}[1-\sigma^2\gamma(1+q^B)f(k^B)] \tag{22}$$

Dividing (21) by (22) and setting $t^A = t^B = 1$ and $q^A = -q^B = 1/2$ one obtains after rearranging

$$\frac{f'(k^B)}{f'(k^A)} = \frac{1-\sigma^2\gamma f(k^A)/2}{1-\sigma^2\gamma f(k^B)/2} \tag{23}$$

For $f''(k)$ □ 0 a solution to this equation requires $k^A = k^B$. To see that, note first that nominator and denominator of the right-hand-side of equation (23) are larger than zero since otherwise the marginal utility of capital in terms of more second period consumption is negative as can be seen from equation (22). Imagine now an equilibrium with $k^A > k^B$: the right-hand side of (23) is then smaller than one, while the left hand side of the equation is at least one, thus ruling out solutions with $k^A > k^B$ (and vice versa solutions for $k^A < k^B$). Hence, the households in both countries invest the same amount of capital; thus expected output is also be equal. From (18) it can be then seen that there is no premium on the swap: $p = f^B - f^A = 0$. Since the solution is symmetric in every respect, there can be no net holdings of bonds of the households in either country, thus $b^A = b^B = 0$.

2.6 Discussion of the Results

The non-zero capital taxation stems from the two externalities present in the model. One externality, as already mentioned, is posed by the capital investment decision: investment by a household raises average output and thus reduces the payments from the swap for all households in the country. The government internalizes this externality by levying a capital tax on investments depending on the size of the externality (the externality is the higher, the higher the amount of shorted output). The second, less direct, externality originates from trading in the macro market: as a household goes short in its own countries output, this causes the government to increase taxes in order to internalize the first externality and leads so indirectly to a distortion in each households investment decision.[16] This externality cannot be internalized in the model, hence the distorting taxation arises. Since

[16]If both countries were populated by a single representative household only, none of the externalities would be present and the households would in equilibrium hold no swaps. This would result in constrained pareto-optimality.

the households choose in equilibrium to diversify by shorting half of its own countries output, a capital tax of 100% is needed to internalize the first externality. The intuition is as follows: additional production is only welfare enhancing if the marginal productivity is at least twice as high compared to the equilibrium of a world without macro markets (since half of the additional output goes to the other country). Regarding the change in welfare of the countries as represented by the utility of a household, there are two effects: first, expected utility increases since the variance of second period consumption can be reduced by 1/2.[17] Second, there is a reduction in welfare because of a distortion of the production due to the capital tax. The latter effect dominates if the risk-aversion is low, because then the first effect is very small while the second remains the same (countries swap half of their output independent of the size of the risk-aversion) but welfare may increase if risk-aversion is high (for the case of quadratic utility and a standard deviation of output of 10%, appendix B shows that there will be a welfare reduction for all admissible values of the risk aversion). For 'real' economies it is clear that there are losses due to a punishment of investment by a 100% capital tax. The allocation is thus no constrained pareto-optimal.[18] It is exactly the externality problem (which arises because the swap contracts on aggregate values rather than individual ones and the fact that the risk sharing is obtained by individuals) that makes the prediction of the model different from other models of moral hazard and risk sharing. If, alternatively, the governments would enter the aggregate risk sharing agreements (as in Green[1987]) or individuals enter risk sharing agreements conditioning on individual output (e.g., Kocherlakota [1998]), they would realize that the more they wish to insure, the lower claims to their output would be valued. This is the case because the investors realize that with an increasing degree of insurance the moral hazard problem rises and price this into the risk

[17] From budget equation (2) one obtains:

$$\begin{aligned} q = 0 \Rightarrow Var(c_2^A) &= Var(b^A(1+r) + f(k^A)(1+\varepsilon^A)) = \sigma^2 (f^A)^2 \\ q = 1/2 \Rightarrow Var(c_2^A) &= b^A(1+r) + f(k^A)(1+\varepsilon^A) + \\ & \quad q^A[f(k^B)(1+\varepsilon^B) - f(k^A)(1+\varepsilon^A) - p] \\ &= 1/4\sigma^2[(f^A)^2 + (f^B)^2] = 1/2\sigma^2(f^A)^2 \end{aligned}$$

[18] To see this, notice that a social planner could enforce an allocation where nobody trades in the swaps.

sharing instruments. Magill and Quinzii (1998) have shown that in a setup with individual risk and individual moral hazard, this mechanism leads to allocations in which full possible insurance is not obtained. Allocations are moreover constrained pareto-efficient. This argument of what is essentially coinsurance breaks down here since the individual household cannot change the valuation of the risk sharing instrument because the latter conditions on aggregate output and thus obtains maximum insurance.

It should be noted that taxation in the model does not arise because of the governments pursuing interests contradicting the interest of the households in the first place: the governments maximizes the utility of their countries households. But in doing so, it creates the distortion. If the governments would not care about households utility, the first best would be achieved![19]

2.7 The Assumptions of the Model

The model makes some important assumption about the incompleteness of the contracts and their enforceability, the observability of countries output and the lack of commitment possibilities for the government. In the following, these assumptions will be discussed.

Incompleteness of the Contracts The model assumes that the only tradable risk sharing instrument is a swap in the countries output. It is easy to see that if it could also be contracted on the tax rate, the first best solution is obtained: the contract would simply require the payment of a sufficiently high penalty for the residents of a country where the tax rate is not zero. While such a contract could be feasible for the above model of capital taxation, it should be kept in mind that capital taxation just stands as an example for policies which reduce output at the benefit of an other policy

[19] The result that a benevolent government may not be optimal is not new. In the case of central banks it is well known that appointing a central banker which is more conservative than the public may be preferred (Eijffinger et. al.[1995]). In the case here, the public could elect a government which also puts weight on the utility of foreign agents. The rationale for this is that taxation aims at increasing payments for domestic households through the swaps but, of course, this will increase the payments of foreign households by the same amount. If the government puts equal weight on domestic and foreign households, the only effect of taxation will be a distortion, thus the government will set the tax rate to zero. However, in practice, the election of a government which cares equally about foreign agents will have further consequences which may not be desired by the domestic households.

goal. A contract which shall achieve the first best would need to condition on all these policies, which is not feasible. The present model shall thus simply represent an incomplete market setting where contracts cannot condition on all possible government instruments.

Enforceability International contracts are typically subject to enforceability problems because countries are sovereign.[20] The scope for default reduces here from the outset since the contracts are not made between governments but by individuals: the households are simply subject to the private law of the country in which the trade is based. However, this is not a sufficient conditions: the government could simply protect domestic individuals against legal suits (or even deter them from making payments in case the individuals want to fulfill obligations, see Diaz-Alejandro[1983] for a historical example). Nevertheless, appropriate design of the settlement of the swaps can solve the problem. Analogous to existing practice in future markets, the exchange organizing the trade could simply require a margin from the households to be paid in advance (as a kind of security). The swap itself is then marked to market on a periodical basis (i.e., daily), the resulting gains and losses for the households in the two countries are credited and debited to their margin account. If the deposits fall below a certain threshold, the households have to make additional payments. If they refuses to do so (or the government deters him from doing so), the swap contract is simply terminated. This does not result in any losses for the other side of the contract, simply because the value of the contract at the time of default is be zero (since it is marked to market). If such a technique is applied to the settling of the swaps, then trade in these swaps do not pose any problems different from existing trade in futures (which is also international!).[21]

Observability of the Countries Output In fact, alternatively to taxing capital, the government could simply underreport the output (or tar-

[20] See Obstfeld and Rogoff [1996], chapter 6.1, for a treatment of the enforceability problem.

[21] For a more detailed description of the settlement of futures, see Hall (1993), chapter 2. To apply the proposed technique to the model requires some adaptations: first, there has to be frequent trading in the swap between the two periods. Moreover, the shocks ε^A and ε^B have to be reinterpreted as the sum of small shocks occurring between the two periods. Further technical complications arise such as the pricing of the contracts (now also capital gains and losses are possible) which will not be discussed further here.

get production towards non-market activities) if output cannot observed by other parties. This problem has already been recognized by Shiller (1993). He suggests a group of experts who design indices for measuring the output of a country. In terms of the model, settlement in the swaps would then take place on basis of the calculations of these experts.

Commitment of the Government The model assumes that the government cannot commit. If however, the government can commit to a certain tax rate, the first best could be achieved by committing to a zero tax. It seems interesting to extend the above model to a dynamic model where the government concerns about its reputation, for example because the detection of adverse behavior of the government could result in exclusion international risk sharing markets (similar to the analysis in Obstfeld and Rogoff[1996], chapter 6.1., where the scope for sovereign default is reduced by the threat of exclusion from international financial markets or Atkeson[1991]). However, the following problems do arise. First, unlike in models of sovereign default the government is not part of the contract, thus sanctions against it are difficult to justify. Moreover, as argued above, the government has many policies of affecting output. Even if it wants to commit, it would have to do so by committing on virtually all kinds of policies. Lastly, not all of the policies can be observed by outsiders (not to talk of verification!), thus even if the government does not stick to its commitment, this cannot easily be detected. It is thus difficult to imagine, what form commitments may take and how reputational arguments shall work, the model thus refrains from issues of commitment (and a dynamic analysis). In section 4 however, the issue of governmental commitments will be discussed further.

3 Extensions

In the following, some modifications to the model will be discussed. The focus is on the question whether there are, despite the finding of welfare losses in the model, incentives to introduce these markets. This is of interest for the policy considerations in section 4. Such incentives could exist for private profit-seeking organizations, further for some of the governments in case countries are affected differentially by the macro markets (such that they are welfare enhancing for some countries while reducing welfare on the world level). Further, it is of interest whether the findings of the model will

emerge as robust.

The Timing The model assumes that the government sets the tax rate after trade has taken place in the swaps. If the government can set the tax rate before trade takes place (but cannot change the taxation afterwards), the government can in fact commit to a tax rate and sets the tax rate to zero (first best). In reality however, government can change the taxes at any time. If this is the case, taxation remains at 100%. The reason for this is as follows. The model shows that there is no influence of government behavior on the markets (in terms of volume). Thus, no matter what the government does, households hold half of world output at the end of the first period (before investment takes place) and the government reacts to this with a taxation of 100%.

The Small Country Case In the case of B being a small country, it can be shown (see appendix C) that the share of output insured is larger than $1/2$ in B and smaller than $1/2$ in A. Moreover, households in A have to pay a premium to the households in B. This is the case since, in contrast to the symmetric case, the demand for long positions in the swap is higher (there are now more households in A). Consequently, this drives the maturity price of the future up. Further by means of simple arithmetic, average swap positions per household in A have to be smaller than in B. Capital taxes in B are then higher than in A reflecting the higher amount of output insured. The overall effect on welfare is not obvious: on one hand, due to the introduction of the markets the households in B can insure large parts of their output and receive moreover a payment for entering the swap contract, but on the other hand there is a higher capital tax.

A World With More Than Two Countries As the number of nations increase, households have more diversification possibilities and thus wish to short a larger part of their countries output in return. This causes an even higher capital taxation by the government for all countries.

Differences in Output Variances If the riskiness of the output differs between the countries, they swap, as shown in appendix D, half of their output in the case that both have the same expected output. Moreover, there

is no premium to be paid on future positions by either of the two sides.[22] Thus the country with the higher output variance gains relatively more due to the higher (absolute) reduction in consumption volatility although both have to bear the same capital tax.[23]

Unilateral Claims In our model, due to the construction of the swap, households are forced when buying claims to foreign output also to short their own nations output. It is this shorting which causes the government to levy a tax. One could ask whether results change if one allows for two futures being traded instead: one a claim to country A's-output and the other to country B's? As shown in appendix E, equilibrium positions in these two futures exactly replicate the former positions in the swap, thus households still short half of their countries income. Hence taxation does not change.

The consideration of unilateral claims gives rise to another interesting question: What happens if there is only one unilateral claim? Appendix E reveals that the equilibrium future positions in the two future markets are independent, thus removal of one market does not effect the outcome in the other market. Imagine a world were there is only one future traded: a claim to countries A's output. Then appendix E shows that country B buys half of country A's output.[24] The government in B does not raise a tax since there are no externalities involved in investment while capital tax in country A is still 100% since half of the output is shorted. Country B gains from the introduction of the future due to the new investment possibility, country A has despite the gains from the introduction from the market also to bear the costs of the distortion.

[22] In the case of B having a higher variance than A and expected output in A being higher than in B, the share of output swapped will be smaller than $1/2$ and households in A will have to pay a premium on the swap. If expected output in A is smaller than in B, more than half of the output will be shared and households in A receive a premium (see appendix D). Taxation will vary accordingly but will be identical across countries.

[23] This and the above results for the multi-country and small country-case are well known regarding the asset positions, see for example Shiller (1997). However, the diversification triggers here a tax response by the governments which will induce additional welfare effects.

[24] The future can be seen as an investment of households in country B in output of country A: they pay a fixed price p_1 and receive an uncertain return $f(k)(1+\varepsilon^A)$. In appendix E it is further shown that the maturity price of the future will be less than the expected output of A, thus there is a positive expected return on the asset.

Macro Markets on a Small Scale For the case of the introduction of a macro market, it will be likely that only a few agents use the new instrument. This may be the case due to different costs of hedging for the agents, or it may simply be the case that an understanding of this risk-managing concept still has to be developed in the population (as argued in Shiller [1993]). How does the government tax in such a setting? Can a macro market on a small scale have positive welfare effects for the households active in the market while being detrimental to the others? To answer this question, consider the above model and moreover assume that the macro markets are only available to a fraction r of the population of the two countries ($0 < r < 1$), called the active households. These households still want to swap half of their output, thus $q^A_{i\square r} = 1/2$ and $q^B_{i\square r} = -1/2$, while the rest of the households is per assumption not engaged in the future: $q^A_{i>r} = 0$ and $q^B_{i>r} = 0$. The resulting average positions in the market are $q^A = rq^A_{i\square r} + (1-r)q^A_{i>r} = r/2$ and $q^B = rq^B_{i\square r} + (1-r)q^B_{i>r} = -r/2$. The governments set the tax rate according to equation (9) to $t^A = q^A/(1-q^A) = r/(2-r) = t^B$.[25] Thus, all households suffer losses due the distortionary tax but the in the macro market active households also gains from diversification. By making r small, the losses per household can be made arbitrarily small while the gains per active household remain constant. Hence, there exists a cut-off value $\overline{r}$ such that for all $r < \overline{r}$ the active households gain from the introduction of the market. This can explain in terms of political economy considerations pressure from groups who are likely to be the active ones to introduce the markets. This would typically be financial intermediaries.

Monopolies in the Macro Markets Imagine that a single government considers selling claims to its own output to foreign households in a world where no macro markets do yet exist. In doing so, the government takes two effects into account: first, it can extract monopoly rents by selling the futures at a premium and give the receipts to the domestic households. On the other hand, insuring output results in an optimal capital tax larger than zero which causes an utility-reducing distortion of the investment decision. It is not obvious whether there are situations in which the first effect dominates and thus whether there is an incentive for the government to sell

[25] The size of the negative externalities of investment depends only on the amount of national output insured. Thus the distribution will not matter and equation (9) can be readily applied.

the claims. Consider now however, a (symmetric) multi-country world where the first effect dominates. This results in a race for being the first one to offer these markets since the benefits from introducing a new claim are deteriorating with the number of countries already selling such contracts. The reason for the latter is that competition is higher then and thus monopoly rents decrease (and eventually become zero), moreover demand for such new contracts decreases reflecting the decreasing marginal utility from diversification. Thus, while it may be in the beginning beneficial for a country to sell claims to its own output, once a number of markets have been set up, there are no premiums to be extracted from the future and the distortionary effect dominates.

Private Operation The most obvious case for the introduction of macro markets is by private institutions. They can gain by collecting fees from the traders in these markets. Traders can be households, firms and financial intermediaries, such as pension funds.[26,27] Moreover, in the case of a single or only a few markets, monopoly rents may be extracted.

Other Policy Instruments The model considers a capital tax as the instrument of government policy. In practice however, the government has a whole range of possibilities to decrease output at the benefit of other goals, such as for example ruling longer vacation times or lowering public investment. In principal the same mechanism as in the model will arise: households price the anticipated government taxation into the future but equilibrium swap trade will not change. Thus the full moral hazard problem as described in the model arises.

4 Implications for Policy

4.1 Is There a Need for Action?

Given incentives to introduce the macro markets by private organizations and possibly by some governments, should one worry about the potential welfare

[26] See Marshall (1992) for a treatment of macro swaps designed to hedge firms risk.

[27] Shiller (1997) argues that pension funds will offer tailor-made contracts on top of existing contracts to insure households against aggregate risk. These fund would then go short in macro markets to hedge their risk.

losses? There is of course a chance that governments resists the temptation of carrying out a policy being detrimental to output; if so, one should wait what happens before restrictive measures are taken. For instance, it is sometimes argued that existing international portfolio diversification poses a similar temptation, though one has not yet experienced adverse government behavior due to that.[28] This is in contrast to the models prediction that the government should even react to a small insurance of output. A possible explanation is that such a behavior simply has not been noticed yet. Given that the international diversification is far from being perfect such a behavior had to be small anyway and moreover no government would be keen to make it public.

A further argument also speaks against a policy of wait-and-see: once the markets are introduced they may be difficult to abolish. As seen in section 3, agents who are active in the markets gain differentially more than the other ones and may start lobbying against any government inference. Lastly, a ban of the markets after introduction results in considerable single losses for the domestic households: after the abolition of the markets the government will bring the tax rate down and output increases, this results in transfers from domestic to foreign households through the existing swaps.

4.2 Discussion of Possible Measures

There are two kinds of actions which could be possibly taken: one is to directly restrict trade in the macro markets (or in the extreme case to ban them) or to take measures which reduce the moral hazard. It should be clear that any action had to be initiated by the government since if markets are operated by private organizations they have no incentive to regulate in the first place. This is the case because, first, due to the settlement of the swaps they face no enforceability problems and, second, the demand for the swaps in the market is not affected by the adverse effects of the swaps.[29]

Modification of the Risk Sharing Instruments The results of the model hinge on the incompleteness of the contracts (and thus the market):

[28] This argument is put forward in Shiller (1993). Once could view such a temptation in terms of the model as the government riding a policy of reducing profits of internationally owned firms at the benefit of domestic agents (e.g., a profit tax).

[29] It has been shown above that $q = 1/2$ no matter what the taxation of the government is.

neither it is possible to contract on the states of natures (i.e., the shock), nor can capital taxation or investment be observed. The justification for the first assumption is simply that states of nature cannot be observed or verified. The latter assumptions were justified in section above by recognizing that the capital tax acts for other government policies, to include all of them into the contract is not feasible. Nevertheless, it may be worthwhile to further interrogate into feasible contracts which condition on variables beside the nations output and look at their equilibrium effects on welfare. This may be in the spirit of the existing literature on moral hazard,[30] however with specific restrictions on the feasibility of the contracts.

An interesting extension to the model even if one sticks to the assumptions on the incompleteness of the markets is to combine the swaps with options on countries outputs. The thus resulting non-linearity may make it difficult to internalize households behavior by taxation and other measures.[31] Magill and Quinzii (1999) for example show that the introduction of options can ensure the first best in a stock market equilibrium with individual moral hazard.

The Government Commits Throughout the paper it was assumed that the government cannot commit, this was rationalized by the complexity of the possible policy instruments, their non-observability and the fact that the government is not part of the risk sharing contracts in the first place. However, it may plausible to assume that in the long run adverse government actions may be detected. The resulting loss of reputation may cause exclusion from the risk sharing markets and further consequences such as unfavorable conditions for other international contracts.[32] There may thus be potential scope for commitments.[33] However, it is not clear how this idea could be transferred into an concrete incentive for the current government given the length of political cycles.

[30] There exists a wide range of literature studying optimal contracts under moral hazard, for example Grossman and Hart (1982) and Brander and Spencer (1989) which concerns about the manager of a firm being subject to moral hazard. However, their concepts cannot readily be applied since here the agent who enters the contract (the household) is not the one who is subject to moral hazard (the government).

[31] This may be especially true in the case of heterogenous agents.

[32] For an analysis in this spirit see Atkeson (1991)

[33] There may also be psychological arguments: the government may, beside its re-election probability, also concern about heading a country with economic prosperity (status) and put weight on domestic output itself.

A potential way to overcome the problems caused by the time inconsistency is to create an independent organization which watches the government. Payments from the contracts would then be made contingent on decisions of this institution. For example, if the institution finds the government to have behaved adversely, settlement could take place by setting the output of the country in question to zero. The advantage of this approach is that it does not require the government to commit or to bind itself into a contract. The institution who watches the government would be set up by the private organization offering the macro market and individuals would have to agree to the settlement conditions. A government facing households who are insured through such contracts may then think twice before it runs the risk of being found to behave adversely. However, it is very difficult for such an institution to objectively decide about the governments behavior. Even if governmental behavior were fully observable, it cannot be deducted whether a certain policy is really meant at reducing output or whether it is just an optimal response of the government to changed economic conditions (such as a shock). Surely, there are cases where the institution takes a wrong decision. The resulting risk for the households may be larger than the potential gains from the reduction in risk through the contracts. Furthermore, the setup of such an institution causes considerable costs.

Changing Government Incentives Another approach is to directly change the incentives for the government by giving politicians rewards depending on the countries output. This clearly sounds futuristic. However, such rewards are already proposed for monetary policy issues[34] and should be taken into account for further discussion.

Restricting Trade in the Market By banning macro markets, governments could get rid of all the problems mentioned above, however, the advantages of these markets would be gone as well. Alternatively to a ban, governments could also tax the contracts so as to internalize the negative externalities arising from it. This would leave the possibility of welfare gains in case of heterogeneous agents: households with a high risk-aversion may still find it worthwhile to engage in the market. A further less stringent action is to forbid short selling in its own output and thus keeping the opportunity

[34] Walsh (1995) outlines the theoretic rationale for such contracts.

to diversify by buying claims to foreign output. However, this would considerably reduce the gains since now households cannot hedge own income anymore.

But would a ban of macro markets be effective at all? A unilateral ban will not be since the location of the macro market is independent of the assets traded: other countries can provide these markets as well. In fact only a single country providing these macro markets would be needed to make the bans ineffective. This country could in fact extract large monopoly rents by selling hedging contracts to other countries of the world.[35] The problem clearly becomes an international issue: bans are only effective if either markets are banned worldwide, otherwise capital mobility has to be restricted.

5 Summary and Conclusions

This paper asked whether risk-sharing achieved by asset trade can induce a change in government policy and thus have, beside the gains from risk-sharing, further welfare effects. The paper considered international risk sharing which is obtained by trading in assets that are claims to countries output (macro markets). The issue was addressed within the context of a general equilibrium model of two countries with stochastic production where an asset market with a swap in national output exists and the government can levy capital taxes. The motivation for the introduction of the tax is that the government can use it to distort investment decisions against production and thus to increase the payments from the swap for the domestic households. It turns out that even though households anticipate such government behavior, they still sell half of their countries' output as in the case without capital taxes. The effect arises because households do not take the negative externalities of holding positions in the contract into account. Ultimately, this results in a capital tax of 100%. Gains from diversification are therefore opposed by losses due to the distortion, the overall effects are likely to be negative. Although the model uses a capital tax as the government instrument, this is not the only instrument to react to an insured output: labor taxation for example does so as well; in general all policies which affect output. It should be further emphasized that the analysis did not rely on particular assumptions such as a specific utility function. The paper also considered some extensions

[35] This country would occupy a similar niche as existing 'tax heavens' do for example.

to the model, they left the predictions regarding a high taxation basically untouched but also suggested that differential welfare effects for the countries can arise. The somehow counterintuitive finding of a likely welfare reduction through the introduction of a new risk sharing market is in stark contrast to the existing literature.[36] It arises, first, because of the separation of the agent who is subject to moral hazard from the agent who actually makes the risk sharing agreements and, second, because the latter cannot change the valuation of the risk sharing assets through its own behavior (since aggregate risks are shared). This setup would also motivate a more detailed analysis of new type of contractual relationship, namely a principal-agent model in which a set of identical agents themselves elect a further agent (the government) and delegate some power to him (taxation).

Since private institutions can gain by introducing macro markets (they can collect fees or receive monopoly rents) and further some governments may have an incentive to introduce these markets, unregulated macro markets would in the light of the results pose a serious threat. Moreover, continuing international asset diversification by means of conventional markets causes similar problems. The paper considered macro markets as the origin of insurance of the countries' production, however, international equity markets can lead to insurance as well: if the equities of a country are mainly hold by foreigners, this amounts to insurance of the profits of the country. Similar incentive problems will arise.[37] The paper then examined some measures which can possibly overcome the problems caused by the markets. One direction of such measures targets toward a richer financial structure by extending and adding risk sharing contracts. Another direction deals with commitments of the government and an institution which watches the government. However, the discussion reveals that no readily available way out seems to be available, a more detailed examination is needed (which is behind scope of paper). Lastly, the paper considered some versions of restricting the trade in the market. Here issues are not simple as well, e.g., a total ban is only effective if carried out on a supranational level.

[36] E.g., in Green (1987), Kahn (1988), Greenwood and Williamson (1989), Gertler and Rogoff (1990), Kocherlakota (1998) and Magill and Quinzii (1998 and 1999) welfare can not shrink due to the new markets.

[37] The reason for concentrating on macro markets in this paper is purely for simplification, considering trade in equity will raise complications such as the relationship between profits and production of a economy and the problem that not all of the equity of a country is traded, thus a high degree of insurance cannot easily be obtained.

It is sometimes argued that moral hazard is not really posing a threat since a high degree of international risk sharing is unlikely to arise due to problems of enforceability and the moral hazard problem itself. The analysis contradicts this view for the following reasons. First, already a very small part of the country being insured triggers an adverse behavior by the government. Second, problems of enforceability are reduced due to the construction of the risk sharing instruments. Lastly, and most important, the model shows that the threat of moral hazard itself does not restrict the risk sharing.

The paper was targeted at risk-sharing in output, however similar problems should be expected for other macro markets as well: whenever a centralized body can influence the pay-offs from the contract, there will the temptation to exploit this.[38] The paper moreover contributed to the literature on asset markets and moral hazard. It challenges the result that asset trade leads to constrained pareto-optimal allocations when trades are observable: if assets are traded across heterogeneous agents, government inference can make the second best not achievable.[39] Since these models partly aim at explaining the equity premium and the home bias puzzle, the findings can possibly have some implications for these puzzles. This is left for future research. Lastly, the model gives an example for the case that the introduction of a new market leads to a welfare reduction, in contrast to other examples in the literature, the effect does not rely on feedback to existing markets.

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[38] One could for example think of a market where claims to sectoral wages are traded. The government could exploit this to carry out a sectoral policy. Also unions will face changed incentives.

[39] In the model, all actions are known to the agents in equilibrium. Thus making trades explicitly observable does not alter the results.

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A Appendix: Swap Positions in the Assymmetric Equilibrium

Proof that for $f^A > f^B$ the following expression

$$\frac{\gamma(c_2^A)(f^A)^2 + \gamma(c_2^B)(f^B)^2}{[\gamma(c_2^A) + \gamma(c_2^B)][(f^A)^2 + (f^B)^2]} \tag{24}$$

is larger than 1/2 if $\gamma(c_2^A) > \gamma(c_2^B)$ and smaller than 1/2 if $\gamma(c_2^A) < \gamma(c_2^B)$.

Proof.

$$\frac{\gamma(c_2^A)(f^A)^2+\gamma(c_2^B)(f^B)^2}{[\gamma(c_2^A)+\gamma(c_2^B)][(f^A)^2+(f^B)^2]} > \frac{1}{2} \Leftrightarrow$$

$$\gamma(c_2^A)(f^A)^2+\gamma(c_2^B)(f^B)^2 > \frac{[\gamma(c_2^A)+\gamma(c_2^B)][(f^A)^2+(f^B)^2]}{2}$$

$$\Leftrightarrow \gamma(c_2^A)(f^A)^2+\gamma(c_2^B)(f^B)^2 > \gamma(c_2^A)(f^B)^2+\gamma(c_2^B)(f^A)^2$$

$$\Leftrightarrow (\gamma(c_2^A)-\gamma(c_2^B))((f^A)^2-(f^B)^2) > 0 \blacksquare$$

B Appendix: Welfare Analysis for Quadratic Utility

First, an expression for the utility of the households before the introduction of the swaps will be computed. In the absence of a macro market, taxation is zero ($t^A = t^B = 0$). Since countries are symmetric and households are identical, there can be no holdings of bonds $b_i^A = b^A = b_i^B = b^B = 0$. The budget equations (1) and (2) simplify to (dropping individual and country subscripts):

$$c_1 + k = y_0 \tag{25}$$

$$c_2 = f(k)(1+\varepsilon) \tag{26}$$

Individuals maximize their intertemporal utility according to

$$U(c_1,c_2) = u(c_1) + \beta E_1[u(c_2)] = c_1 - \frac{\alpha}{2}(c_1)^2 + \beta E_1[c_2 - \frac{\alpha}{2}(c_2)^2] \tag{27}$$

(quadratic utility with risk aversion parameter α) and home production takes place according to a linear production function $f(k) = \delta \cdot k$. The quadratic utility-function makes difficulties in that the (expected) marginal utilities of consumption $1 - \alpha c_1$ and $E_1[1 - \alpha c_2] = 1 - \alpha\delta k$ can become negative for larger values of α, c_1 and δk. To rule this out, it will be required that the following conditions are met:

$$1 - \alpha y_0 > 0 \text{ and } 1 - \alpha\delta y_0 > 0 \tag{28}$$

This ensures that neither when the household invest nothing ($c_1 = y_0$) nor when it invest everything ($k = y_0$) the expected marginal utilities of consumption can become negative.[40] From the condition for the optimal investment (derived from (6)) $u'(c_1) = \beta E_1[u'(c_2)f'(k)(1+\varepsilon)]$ one obtains

$$\begin{aligned} 1 - \alpha(y_0 - k) &= \beta E_1[(1 - \alpha\delta k(1+\varepsilon))\delta(1+\varepsilon)] \\ &= \beta\delta[1 - (1+\sigma^2)\alpha\delta k] \end{aligned} \tag{29}$$

Solving for the k yields

$$k = \frac{\alpha y_0 + \beta\delta - 1}{\alpha + (1+\sigma^2)\alpha\beta\delta^2} \tag{30}$$

Now first and second period consumption can be derived from (25) and (26), from (27) one gets an expression for the utility of a household:

$$U_0 = \frac{1 + \beta^2\delta^2 + \beta\delta(\alpha y_0(2 - (1+\sigma^2)(\alpha y_0 - 2)\delta - 2)}{2(\alpha + (1+\sigma^2)\alpha\beta\delta^2} \tag{31}$$

Next, the utility after the introduction of the swaps will be computed. From section 2.5 it is known that households swap half of the output ($q = 1/2$), that equilibrium taxation is 100% ($t = 1$) and that the price of the future is zero ($p = 0$). The budget equations are then

$$c_1 + T = y_0 + 2k \tag{32}$$

$$c_2 = f(k)(1 + \frac{\varepsilon^A + \varepsilon^B}{2}) \tag{33}$$

where $T = k$ in equilibrium. Plugging this into the equation for optimal investment of a country A household (equation (6)) $(1+t)u'(c_1) =$

[40] However, ex post second period marginal utility (and also second period utility) can always become negative since the shock ε has the interval $(-\infty, \infty)$ as support. This will make it unreasonable to draw inferences from the analysis for high values of the shock variance σ^2 since then negative realizations of second period (marginal) utility become more frequent, see below.

$\beta E_1[u'(c_2)f'(k)(1+\varepsilon^A)]$ yields

$$\begin{aligned} 2(1-\alpha(y_0-k)) &= \beta E_1[(1-\alpha\delta k(1+\frac{\varepsilon^A+\varepsilon^B}{2}))\delta(1+\varepsilon^A)] \\ &= \beta\delta[1-(1+\frac{\sigma^2}{2})\alpha\delta k] \end{aligned} \tag{34}$$

Solving for k gives

$$k = \frac{\alpha y_0 + \frac{\beta\delta}{2} - 1}{\alpha + 1/2(1+\sigma^2/2)\alpha\beta\delta^2} \tag{35}$$

Plugging this into (32) and (33) and subsequently into the utility function (27) gives an expression for the new utility:

$$\begin{aligned} U_1 = \; & \frac{1}{2\alpha(4+(2+\sigma^2)\beta\delta^2)^2}\cdot \\ & (16+\beta\delta(-32+(2+\sigma^2)(y_0)^2\alpha^2\delta(-8-(2+\sigma^2)\beta\delta^2+ \\ & 2y_0\alpha(2+(2+\sigma^2)\delta)(8+(2+\sigma^2)\beta\delta^2)+ \\ & 2\beta\delta(6+(2+\sigma^2)\delta(-2+\beta\delta)))) \end{aligned} \tag{36}$$

For the evaluation of the change in welfare as represented by the difference in households utilities $(U_1 - U_0)$, the productivity and time preference parameter are set to one ($\delta = 1$ and $\beta = 1$). The potential gains from the risk sharing are expected to increase with the variance of the output-shock σ^2 and the degree of risk aversion α (clearly, if either $\sigma^2 = 0$ or $\alpha = 0$, there are no potential gains from risk sharing). To obtain a conservative value for the possible welfare losses, a standard deviation of the output growth of 10% will be assumed (this is a high figure compared for example with a standard deviation of consumption growth of around 3% for the U.S., see van Wincoop[1999]). Plugging this values into the equations for U_0 and U_1, setting the difference to zero and solving for the risk-aversion, one finds that for $\alpha > 1.736/y_0$, U_1 is higher than U_0, otherwise U_1 is smaller than U_0. However, $\alpha > 1.736/y_0$ violates condition (28), in fact first and second period expected marginal utility are negative. Thus, for all admissible combinations of the risk aversion and the endowment, the introduction of the swap leads to a welfare reduction.

The apparent dependence of the sign of $(U_1 - U_0)$ on α and y_0, as suggested by the expression $\alpha > 1.736/y_0$, is simply the result of the fact that with quadratic utility a rising initial endowment y_0 causes the maximum value of the risk aversion which still guarantees positive expected marginal utilities to fall. The effect arises, loosely speaking, because a too large endowment leading to negative marginal utilities (since endowment cannot be destroyed) can make an otherwise inefficient allocation preferable, simply because it reduces the goods available for consumption.

For higher standard deviations of the output ($\sigma = 0.2$ and $\sigma = 0.3$) the limits for α (in fact $\alpha = 1.531/y_0$ and $\alpha = 1.371/y_0$) lie also outside the range of admissible parameters. However, more general results cannot reasonably be obtained since an even higher variance further increases the likelihood of negative ex-post second period utility and second period marginal utility.

C Appendix: Countries With Different Sizes

Imagine that households in country A have a measure of n, while the households in B still have a measure of unity. The market clearing equation for the future market is then $nq^A + q^B = 0$. From the price equations (14) and (15) one obtains for constant absolute risk-aversion:

$$q^A = \frac{1}{n+1}, q^B = \frac{n}{n+1}, p = f^B - f^A + \sigma^2\gamma\frac{n(f^A)^2 - (f^B)^2}{n+1} \tag{37}$$

Independent of the output in the two countries, $\frac{n}{n+1}$-swaps are traded. This number rises with an increase in the size of A (in the limit case $n \to \infty$, country B will fully insure its output). If average output in B is not larger than in A, it can be seen that the premium to be paid by households in A

$$\sigma^2\gamma\frac{n(f^A)^2 - (f^B)^2}{n+1} \tag{38}$$

is positive and rises with n. Plugging the values for q^A and q^B in the equation for the optimal taxation (9) gives: $t^A = 1/n$ and $t^B = n$.

D Appendix: Countries With Differing Out-

put Variance

Let σ^A and σ^B the standard deviations of the output shocks in countries A and B. Then one can obtain the swap pricing equations (14) and (15) for constant absolute risk-aversion:

$$\begin{aligned} q &= \frac{(\sigma^A)^2(f^A)^2 + (\sigma^B)^2(f^B)^2}{[(\sigma^A)^2 + (\sigma^B)^2][(f^A)^2 + (f^B)^2]}, \\ p &= f^B - f^A + \gamma(\sigma^A)^2(\sigma^B)^2\frac{(f^A)^2 - (f^B)^2}{(\sigma^A)^2 + (\sigma^B)^2} \end{aligned} \tag{39}$$

The amount of output swapped is larger than 1/2 in the case of $\sigma^A < \sigma^B$ if $f^A < f^B$ and smaller than 1/2 if $f^A > f^B$ (see appendix A and substitute σ^A and σ^B by $\gamma(c_2^A)$ and $\gamma(c_2^A)$ respectively).

E Appendix: Equilibrium With Two Unilateral Claims to Output

Define futures 1 and 2 which give a claim to $f^A(1+\varepsilon^A)$ and $f^B(1+\varepsilon^B)$ respectively and maturity prices p_1 and p_2. The second period budget equation (2) for a household in country A is then

$$b_i^A(1+r) + f(k_i^A)(1+\varepsilon^A) + q_{1,i}^A[f^A(1+\varepsilon^A) - p_1] + q_{2,i}^A[f^B(1+\varepsilon^B) - p_2] = c_{i,2}^A$$

and for country B

$$b_i^B(1+r) + f(k_i^B)(1+\varepsilon^B) + q_{1,i}^B[f^A(1+\varepsilon^A) - p_1] + q_{2,i}^B[f^B(1+\varepsilon^B) - p_2] = c_{i,2}^B$$

Optimal positions in the future markets in country A require

$$\frac{\partial U(c_{i,1}^A, c_{i,2}^A)}{\partial q_{1,i}^A} = 0! \Rightarrow E_1[u'(c_{i,2}^A)(f^A(1+\varepsilon^A) - p_1)] = 0 \tag{40}$$

$$\frac{\partial U(c_{i,1}^A, c_{i,2}^A)}{\partial q_{2,i}^A} = 0! \Rightarrow E_1[u'(c_{i,2}^A)(f^B(1+\varepsilon^B) - p_2)] = 0 \tag{41}$$

analog for country B. Transforming these equations using Stein's lemma one obtains price equations for country A's positions:

$$p_1 = f^A - \sigma^2\gamma(1+q_1^A)(f^A)^2, p_2 = f^B - \sigma^2\gamma q_2^A(f^B)^2 \tag{42}$$

and for country B

$$p_1 = f^A - \sigma^2\gamma q_1^B(f^A)^2, p_2 = f^B - \sigma^2\gamma(1+q_2^B)(f^B)^2 \tag{43}$$

Using the market clearing conditions $q_1^A + q_1^B = 0$ and $q_2^A + q_2^B = 0$ one obtains $q_1^A = -1/2, q_1^B = 1/2, q_2^A = 1/2, q_2^B = -1/2$. Thus every country shorts half of its own income and is long in half of the foreign income. From (42) and (43) it can be seen further that the respective prices of the futures are $p_1 = f^A - \frac{1}{2}\sigma^2\gamma(f^A)^2$ and $p_2 = f^B - \frac{1}{2}\sigma^2\gamma(f^B)^2$. The maturity price of the future is less than expected output since the long side receives a compensation for the risk of the claim (while the short side has a riskless position).