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International Spillovers and Guidelines for Policy Cooperation

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A Welfare Theorem for National Economic Policymaking*

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Abstract

In an interconnected world, national economic policies lead to international spillover effects. This has recently raised concerns about global currency wars. We show that international spillover effects are Pareto efficient and that there is no role for global coordination if three conditions are met: (i) national policymakers act as price-takers in the international market, (ii) national policymakers possess a complete set of instruments to control the external transactions of their country and (iii) there are no imperfections in international markets. Under these conditions, international spillover effects constitute pecuniary externalities that are mediated through market prices and do not give rise to inefficiency. We cover four applications: policies to correct growth externalities, aggregate demand externalities in a liquidity trap, spillovers from fiscal policy, and exchange rate stabilization policy. Conversely, if any of the three conditions we identify is violated, we show how global cooperation can improve welfare. Examples that we cover include beggar-thy-neighbor policies, countries with imperfect instruments, and incomplete global financial markets.

JEL Codes: F34, F41, H23
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1 Introduction

In a globally integrated economy, national economic policies generate international spillover effects. This has recently led to considerable controversy in international policy circles and has raised concerns about global currency wars.[1] The contribution of this paper is to provide a broad set of sufficient conditions under which national policymaking in pursuit of domestic objectives leads to Pareto efficient global outcomes. In other words, our paper extends the first welfare theorem to the interactions of national economic policymakers in a multi-country setting. Under the conditions that we identify, all international spillover effects are Pareto efficient and there is no case for international policy cooperation. Conversely, our paper describes how international policy cooperation can generate Pareto improvements if one of these conditions is violated.

We develop a multi-country general equilibrium framework that nests a broad class of open economy macro models and that is able to capture a wide range of domestic market imperfections and externalities. We assume that each country encompasses a set of optimizing private agents as well as a policymaker who has policy instruments to affect the domestic and international transactions of the economy. When the policymaker in a given country changes her policy instruments, she influences the actions of domestic consumers, which in turn lead to general equilibrium adjustments that may entail spillover effects to other economies.[2]

We show that the spillovers created by national economic policymaking are Pareto efficient and that there is no need for global cooperation if three conditions are met: (i) national policymakers act competitively, i.e. they act as price-takers in the international market, (ii) if there are domestic externalities, national policymakers either possess a sufficient set of policy instruments to control them domestically or a complete set of external policy instruments, and (iii) there are no imperfections in international markets. Under these three conditions, we can view national policymakers as competitive agents in a well-functioning global market, and so the first welfare theorem applies. Therefore international spillover effects constitute pecuniary externalities that are mediated through market prices and do not give rise to inefficiency. By implication, spillover effects by themselves should not be viewed as a sign of inefficiency.

We obtain our results by observing that, under quite general conditions, we can condense the welfare function of each country into a reduced-form welfare function $V(\cdot)$ in which the only argument is a vector of the country's international transactions. Condition (i) ensures that policymakers are price-takers and that there are

[1] The term "curreny war" was coined by the Brazilian finance minister Guido Mantega in September 2010 to describe policies of the US a number of Asian countries that had the effect of depreciating their exchange rates. For detailed discussions on this subject see e.g. Gallagher et al. (2012), Jeanne et al. (2012), Ostry et al. (2012) and Stiglitz (2012).

[2] For a detailed review of both the theoretical and empirical literature on spillovers, see for example Kalemli-Ozcan et al. (2013).

no monopolistic distortions; condition (ii) of complete policy instruments guarantees that each domestic policymaker has the instruments to implement her desired external allocation subject to a country's external budget constraint; condition (iii), that there are no imperfections in international markets, ensures that the marginal rates of substitution of all countries are equated in equilibrium. As a result, we can apply the first welfare theorem at the level of national policymakers, interpreting $V(\cdot)$ as the utility functions of competitive agents in a complete market. Our model is general enough to allow for a wide range of domestic market imperfections, including price stickiness, financial constraints, incentive/selection constraints, missing or imperfect domestic markets, etc.

If any of the three conditions we identified is violated, spillover effects generally lead to inefficiency, and global cooperation among national policymakers can generally improve welfare. Following the three conditions above, such cooperation works along three dimensions: (i) It ensures that countries refrain from monopolistic behavior and act with "benign neglect" towards international variables. (ii) If countries face domestic externalities but have incomplete/imperfect instruments to address them, then welfare is improved if those countries with better instruments or better-targeted instruments assist those without. (iii) If imperfections in international markets lead to inefficiency, then global coordination is necessary to restore efficiency since the imperfections are outside of the domain of individual national policymakers. We provide examples that characterize the scope for coordination in each of the three cases.

The types of cooperation described in points (ii) and (iii) typically implement second-best equilibria that take the set of available policy instruments and markets as given but make more efficient use of them. There is also a scope for first-best policies in these areas: global cooperation may increase efficiency by creating more or better policy instruments, or by reducing imperfections in international markets.[3] Our analysis suggests that the case for global cooperation disappears the closer we move to the ideal of perfect external instruments and international markets, provided that national economic policymakers continue to act competitively.

We apply our theoretical analysis to a number of practical applications, many of which have led to controversy in international policy circles in recent years. Our first application, chosen because it provides the simplest illustration of our results, is to analyze an economy in which international capital flows generate technological externalities. An important example that is frequently referred to by policymakers in developing economies are learning-by-exporting effects. We show that a national

[3] A number of recent reforms in the global financial architecture follow this principle: for example, Basel III provides policymakers with new counter-cyclical capital buffers (better instruments), recent IMF proposals allow countries to use capital controls (new instruments; see Ostry et al, 2011), and swap lines between advanced economy central banks provide new forms of liquidity insurance (more complete markets). A standard caveat in the theory of the second-best applies: moving closer to the case of perfect markets and perfect instruments does not always imply more efficient outcomes.

policymaker finds it optimal to correct technological externalities via current account or capital account intervention. Furthermore, as long as the three conditions identified above are satisfied, this policy intervention is efficient from a global perspective, i.e. global cooperation cannot achieve a Pareto superior outcome. We extend our analysis to domestic technological externalities and show that our results continue to hold even if capital account intervention is just a second-best policy measure to correct learning-by-doing externalities in the domestic economy.

Our second application describes an economy that suffers from a shortage of aggregate demand that cannot be corrected using domestic monetary policy because of a binding zero-lower-bound on nominal interest rates. In such a situation, a national economic policymaker finds it optimal to impose controls on capital inflows or to subsidize capital outflows in order to mitigate the shortage in demand. Under the three conditions discussed earlier, this behavior leads, again, to a Pareto efficient global equilibrium.

Our third application analyzes the incentives for the optimal level of fiscal spending. If a domestic policymaker chooses how much fiscal spending to engage in based on purely domestic considerations, we show that the resulting global equilibrium is Pareto efficient under the three discussed conditions. In the context of fiscal policy, it is of particular importance that the domestic policymaker needs to act competitively, i.e. with benign neglect towards the international price effects of her policy actions. In particular, if the policymaker strategically reduces her stimulus in order to manipulate its terms-of-trade, then the resulting equilibrium is inefficient and generally exhibits insufficient stimulus. During the Great Recession, this observation has led many policymakers to argue that it is necessary to coordinate on providing fiscal stimulus since part of the stimulus spills over to other countries.

Our fourth application analyzes an economy in which there are heterogeneous domestic agents who face incomplete risk markets and cannot insure against fluctuations in the country's real exchange rate. We show that a national economic policymaker can improve welfare by intervening in the economy's capital account to stabilize the economy's real exchange rate. This constitutes a second-best policy tool to insure domestic agents. Again, the outcome is Pareto efficient under the three conditions identified above. This illustrates that our results on global Pareto efficiency continue to hold even if a national planner pursues purely distributive objectives or implements domestic political preferences, as long as we abstain from paternalism, i.e. as long as the global planning problem that is used to evaluate Pareto efficiency respects those domestic objectives and preferences.

In each of the described applications, we show that the spillover effects from policy intervention are efficient under the idealized circumstances captured by the three conditions for efficiency. Any arguments about the desirability of global policy coordination therefore needs to be made on the basis of deviations from these conditions. Our paper therefore concludes by describing the case for coordination in each of these circumstances.

We continue our analysis by carefully examining the case for economic policy coordination when at least one of the three conditions is violated: When condition (i) is violated and policymakers internalize their market power, coordination should aim to restrict monopolistic behavior so as to maximize gains from trade. This has been well understood at least the rebuttal of mercantilism by Smith (1776).[4] This applies not only to external policy measures but also to all domestic policies that affect international prices, such as e.g. fiscal policy. We add to this literature by providing general conditions for the direction of monopolistic intervention that help to distinguish monopolistic intervention from intervention to correct domestic market imperfections. However, we also show that there are ample circumstances under which it is difficult to distinguish monopolistic from corrective intervention. Furthermore, we show that domestic policies will only be distorted with monopolistic objectives if a country faces restrictions on its set of external policy instruments. For a detailed discussion on how to achieve policy agreements to abstain from monopolistic behavior see Bagwell and Staiger (2002).

Condition (ii) implies that there may be a case for international policy cooperation when policymakers possess an incomplete set of policy instruments. If a country suffers from domestic externalities, we show that the global equilibrium is constrained Pareto efficient if domestic policymakers either have sufficient domestic instruments to directly correct the externalities in the domestic economy (e.g. to stimulate aggregate demand when it is insufficient) or have a complete set of external policy instruments so that the indirect effects of external transactions on domestic externalities can be corrected (e.g. to tax capital inflows when aggregate demand is insufficient). Conversely, if a country suffers from externalities and both domestic and external policy instruments are incomplete, then international policy cooperation can generally achieve a Pareto improvement. Efficient allocations require that countries with better instruments or better-targeted instruments assist those without. For example, if a country experiences externalities from capital inflows but has no instrument to control them, welfare is improved if other countries control their capital outflows.

The observation that incomplete policy instruments make it desirable to coordinate policy has a rich intellectual tradition, going back to the targets and instruments approach of Tinbergen (1952) and Theil (1968). They observed in a reduced-form setting that incomplete instruments may give rise to a role for economic policy cooperation. Our contribution to this literature is to embed the Tinbergen-Theil approach into a general equilibrium framework in which optimizing individual agents interact in a market setting. This leads to a number of novel findings. First, we show that many of the spillover effects that would suggest a role for cooperation in the Tinbergen-Theil

[4] This observation also underlies much of modern optimal tariff theory. See e.g. Bagwell and Staiger (2002) for a modern treatment in the trade literature, or Costinot et al. (2014) and De Paoli and Lipinska (2013) for recent contributions that focus on intertemporal rather than intratemporal trade. Farhi and Werning (2012) emphasize this motive for cooperation in a multi-country New Keynesian framework. Persson and Tabellini (1995) survey implications for macroeconomic policy.

framework actually constitute efficient pecuniary externalities. Once the optimizing behavior of private agents is taken into account, a wide range of spillovers can be considered as efficient. Secondly, monopoly power and incomplete markets create independent roles for cooperation even if the set of policy instruments is complete.[5]

Condition (iii) requires that all international transactions take place in complete markets and at flexible prices to ensure efficiency. This is a well-known condition for the first welfare theorem and has spurred a significant body of literature in the context of general equilibrium models with individual optimizing agents (see e.g. Geanakoplos and Polemarchakis, 1986; Greenwald and Stiglitz, 1986, for a general treatment). In our analysis, we interpret national economic policymakers who abstain from monopoly distortions as competitive agents who interact in an international market and show that the same efficiency results hold.[6]

The remainder of the paper is structured as follows: Section 2 introduces our model setup and examines its welfare properties, stating our main result on when spillovers are efficient. Section 4 provides a number of illustrations of our results. Sections 5 to 7 examine the case for international policy coordination when policymakers act monopolistically, are constrained in their policy instruments or face incomplete international markets. The final section concludes.

2 Model Setup

Our model describes a multi-country economy in which each country consists of a continuum of private agents as well as a domestic policymaker. Both maximize domestic welfare subject to a set of constraints on their domestic allocations and a standard budget constraint on their external transactions. In order to create an interesting role for policy intervention, we distinguish between individual and aggregate allocations so as to capture the potential for externalities. An individual takes aggregate allocations as given, whereas the domestic planner employs her policy instruments to affect aggregate allocation so as to correct for domestic externalities. Our framework nests a wide range of open economy macro models in which there is a case for policy intervention, as we illustrate in a number of examples below.

Countries We describe a world economy with $N \geq 2$ countries indexed by $i = 1, ...N$. The mass of each country i in the world economy is $\omega^i \in [0, 1]$, where $\Sigma_{i=1}^N \omega^i = 1$. A country with $\omega^i = 0$ corresponds to a small open economy.

[5] In the more recent literature, Jeanne (2014) provides an interesting example where the coordination of macroprudential policies is warranted because of missing policy instruments.

[6] Recent applications in an international context include Bengui (2013) who analyzes the need for coordination on liquidity policies when global markets for liquidity are incomplete, and Jeanne (2014) who analyzes a world economy in which agents are restricted to trading bonds denominated in the currency of a single country.

Private Agents In each country i, there is a continuum of private agents of mass 1. We denote the allocations of individual private agents by lower-case variables and the aggregate allocations of the country by upper-case variables.

A representative private agent obtains utility according to a function

$$U^i\left(x^i\right) \tag{1}$$

where x^i is a column vector of domestic variables that includes all variables relevant for the utility of domestic agents, for example the consumption of goods or leisure. We assume that $U^i\left(x^i\right)$ is increasing in each element of x^i and quasiconcave.

To keep notation compact, x^i also includes all domestic variables, including those that do not directly yield utility but that we want to keep track of, for example the capital stock k^i in models of capital accumulation. For such variables, $\partial U^i/\partial k^i = 0$.

External Budget Constraint We denote the international transactions of private agents by a column vector of net imports m^i that are traded at an international price vector Q. Private agents have initial external net worth w_0^i and may be subject to a vector of tax/subsidy instruments τ^i that is imposed by the domestic policymaker. We denote by $\frac{Q}{1-\tau^i}$ the element-by-element (Hadamard) division of the price vector Q by the tax vector $(1-\tau^i)$, which are both row vectors, and by $Q \cdot m^i$ the inner product of the price and quantity vectors. The external budget constraint of domestic agents is then

$$\frac{Q}{1-\tau^i} \cdot m^i \leq w_0^i + T^i \tag{2}$$

Any tax revenue is rebated as a lump sum transfer $T^i = \frac{\tau^i Q}{1-\tau^i} \cdot m^i$. If taxes are zero, then the budget constraint reduces to the *country i external constraint* $Q \cdot m^i \leq w_0^i$.

Domestic Constraints We assume that the representative agent in country i is subject to a collection of constraints, which encompass domestic budget constraints and may include any financial, incentive/selection, or price-setting constraints as well as restrictions imposed by domestic policy measures,

$$f^i\left(m^i, x^i, M^i, X^i, \zeta^i, Z^i\right) \leq 0 \tag{3}$$

where ζ^i is a collection of domestic policy instruments such as taxes, subsidies, government spending, or constraints on domestic transactions; Z^i represents a collection of exogenous state variables, for example endowments, productivity shocks or initial parameters.

Observe that we include both the individual external and domestic allocations (m^i, x^i) and aggregate allocations (M^i, X^i) in the constraint to capture the potential for externalities from aggregate allocations to the choice sets of individuals, which we will analyze further in the coming sections. The choice variables of the representative agent are (m^i, x^i) and he takes all remaining variables in the constraint as given.

In summary, the optimization problem of a representative domestic agent is to choose the optimal external and domestic allocations (m^i, x^i) so as to maximize utility (1) subject to the collection of domestic and external constraints,

$$\max_{m^i,x^i} U^i\left(x^i\right) \quad \text{s.t.} \quad (2),\,(3) \tag{4}$$

Domestic Policymaker The domestic policymaker sets the domestic policy instruments ζ^i and external policy instruments τ^i in order to maximize the utility (1) of domestic private agents subject to the domestic and external constraints $f^i(\cdot) \leq 0$ and $M^i \cdot Q \leq w_0^i$. The policymaker internalizes the consistency requirement that the allocations of the representative agent coincide with the aggregate allocations so $m^i = M^i$ and $x^i = X^i$. Furthermore, the policymaker internalizes that these allocations (m^i, x^i) have to solve the optimization problem of domestic agents as described by problem (4).

Feasible Allocations We define a *feasible allocation in country i* for given world prices Q and parameters (w_0^i, Z^i) as a collection $\left(X^i, M^i, \zeta^i\right)$ that satisfies the country i domestic and external constraints $f^i(\cdot) \leq 0$ and $M^i \cdot Q \leq w_0^i$.

Furthermore, we define a *feasible global allocation* for given $(w_0^i, Z^i)_{i=1}^N$ as a collection $\left(X^i, M^i, \zeta^i\right)_{i=1}^N$ that satisfies $f^i(\cdot) \leq 0 \forall i$ and $\sum_{i=1}^N \omega^i M^i \leq 0$.

To make our setup a bit more concrete, the following examples illustrate how a number of benchmark open economy macro models map into our framework:

Example 2.1 (Baseline Model of Capital Flows) Our first example is a simple model of capital flows between neoclassical endowment economies $i = 1, ...N$ with a single consumption good in infinite discrete time. Assume that the domestic variables in each economy i consist of a vector of consumption goods $x^i = \{(c_t^i)_{t=0}^\infty\}$ and that the vector of external transactions $(m_t^i)_{t=0}^\infty$ denotes the imports of the consumption good in each period, which is equivalent to the trade balance. Since there is a single good, we can also interpret m_t^i as the net capital inflows in period t. Furthermore, there are no domestic policy instruments so $\zeta^i = \varnothing$ and the vector of exogenous variables Z^i consists of an exogenous endowment process $(y_t^i)_{t=0}^\infty$.

Assume the utility function in each country is given by $U^i(x^i) = \sum_t \beta^t u(c_t^i)$ and the domestic constraints contain one budget constraint for each time period so $f^i(\cdot) = \{f_t^i(\cdot)\}_{t=0}^\infty$ where $f_t^i(\cdot) = c_t^i - y_t^i - m_t^i \leq 0$. If we normalize $Q_0 = 1$ then each element of the vector Q_t represents the price of a discount bond that pays one unit of consumption good in period t, and the external budget constraint of the economy is given by (2). This fully describes the mapping of a canonical open economy model into our baseline setup.

The policymaker's vector of external policy instruments $\tau^i = (\tau_t^i)_{t=0}^\infty$ can be interpreted as capital controls according to the following categorization:

	$\tau_t^i < 0$	$\tau_t^i > 0$
$m_t^i < 0$ (net saving)	outflow tax	outflow subsidy
$m_t^i > 0$ (net borrowing)	inflow subsidy	inflow tax

Table 1: Interpretation of capital control τ_t^i

For example, if a country is a net importer $m_t^i > 0$ (i.e. experiences net capital inflows) in period t, a positive tax rate $\tau_t^i > 0$ raises the cost of the imports/inflows so the measure represents an inflow tax on capital.

It is common in the open economy macro literature to keep track of the external wealth position w_t^i of a country over time and denote the external budget constraint (2) by the law of motion of the external wealth position together with a transversality condition $\lim_{t\to\infty} Q_t w_t^i = 0$. Given the country's initial external wealth w_0^i, this law of motion can be represented by the series of period-by-period constraints

$$\frac{\left(1-\xi_{t+1}^i\right) w_{t+1}^i}{1+r_{t+1}} = w_t^i - m_t^i + T_t^i \qquad \forall t$$

where the interest rate r_{t+1} corresponds to the relative price of discount bonds in two consecutive periods, $1 + r_{t+1} = Q_t/Q_{t+1}$, and the period capital control ξ_{t+1}^i corresponds to the increase in the cumulative controls, $1-\xi_{t+1}^i = \left(1-\tau_t^i\right) / \left(1-\tau_{t+1}^i\right)$. The revenue from any controls is rebated in lump sum fashion T_t^i in the period it is raised. The Arrow-Debreu formulation and the period-by-period description of our setup are equivalent, and we will use both in our applications below.

To extend our example to a stochastic economy, all that is required is to define a set of states of nature Ω and a series of probability spaces $(\Omega, \mathcal{F}_t, P_t)$ such that $\mathcal{F}_t$ defines a sigma-algebra of states measurable at time t and satisfying $\mathcal{F}_t \subseteq \mathcal{F}_{t+1}$ and P_t is a probability measure defined over each $\mathcal{F}_t$ with an associated expectations operator $E_t[\cdot] = E[\cdot|\mathcal{F}_t]$. Then we can label all variables by both time t and state of nature $s \in \Omega$, for example $x^i = \left\{\left(c_{s,t}^i\right)_{s\in\Omega,t=0}^{\infty}\right\}$, and define utility as $U^i(x^i) = E_0[\sum_t \beta^t u\left(c_{s,t}^i\right)]$. Everything else remains unchanged.

Example 2.2 (Production Economy with Capital Flows) Next we describe capital flows in a world of neoclassical production economies. We build on example 1 and include leisure, investment, and capital in the collection of domestic variables so $x^i = \left\{(c_t^i, \ell_t^i, i_t^i, k_{t+1}^i)_{t=0}^{\infty}\right\}$ where labor in a given period is $1-\ell_t^i$. The vector of exogenous variables contains the initial capital stock and the path of productivity, $Z^i = \{k_0, (A_t^i)_{t=0}^{\infty}\}$. We extend the utility function to include leisure $U^i(x^i) = \sum_t \beta^t u(c_t^i, \ell_t^i)$. The collection of domestic constraints consists of a budget constraint $f_{t,c}^i(\cdot)$ and a capital accumulation constraint $f_{t,k}^i(\cdot)$ each period, which we denote by

$$\begin{aligned} f_{t,c}^{i}\left(\cdot\right) &= c_t^i + i_t^i - A_t^i \left(k_t^i\right)^{\alpha} \left(1-\ell_t^i\right)^{1-\alpha} - m_t^i \le 0 \\ f_{t,k}^{i}\left(\cdot\right) &= k_{t+1}^i - \left(1-\delta\right) k_t^i - i_t^i \le 0 \end{aligned}$$

As in example 1, m_t^i equivalently captures net imports and capital inflows, and the policy measure τ_t^i can be interpreted as import taxes or as capital controls as in Table 1. The framework can be extended to stochastic shocks as described before.

Example 2.3 (Multiple Consumption Goods) The framework of our previous examples can also be extended in the direction of multiple consumption goods. Expanding on our baseline model in example 1, all that is required is to define the variables c_t^i, m_t^i, y_t^i and τ_t^i in each time period as vectors of size K capturing the consumption, net imports, endowment and inflow taxes on each good $k = 1...K$ in period t. Utility can then be written as $U^i\left(x^i\right) = \sum_t \beta^t u\left(c_{t,1}^i, ..., c_{t,K}^i\right)$. If some of the consumption goods are non-traded, we omit them from the vector of net imports m_t^i so that $\dim m_t^i = K_T < K$.

Assuming that τ_t^i is a vector of equal size as m_t^i supposes that the planner can set differential tax/subsidy rates on each traded good $k = 1...K_T$. Alternatively, assuming that the planner can only differentiate taxes by time period would amount to a restriction on the set of instruments $\tau_{t,1}^i = ... = \tau_{t,K_T}^i\ \forall t$. We will analyze such restrictions in Section 6.

3 Equilibrium

Definition 1 (Global Competitive Equilibrium) *For given initial conditions $(w_0^i, Z^i)_{i=1}^N$, an equilibrium in the described world economy consists of a set of feasible allocations $\left(X^i, M^i, \zeta^i\right)_{i=1}^N$ and external policy measures $(\tau^i)_{i=1}^N$ together with a vector of world market prices Q such that*

- the individual allocations $x^i = X^i$ and $m^i = M^i$ solve the optimization problem of private agents for given prices Q, aggregate allocations $\left(X^i, M^i, \zeta^i\right)$ and external policy measures (τ^i),
- the aggregate allocations $\left(X^i, M^i, \zeta^i\right)$ and external policy measures (τ^i) solve the optimization problem of domestic policymakers for given prices Q and
- markets for international transactions clear $\sum_i^N \omega^i M^i = 0$.

A formal description of the optimization problems of private agents and domestic policymakers is provided in appendix A.1.

In the following two subsections, we separate the analysis of equilibrium in the world economy into two steps. The first step is the domestic optimization problem of each economy for a given external allocation (m^i, M^i) and is described in the next subsection. We show that the welfare of each country can be expressed as a reduced-form utility function $V^i(m^i, M^i)$ that greatly simplifies our analysis. The second step solves for the optimal external allocation of the economy given $V^i(m^i, M^i)$ for each country and is described in the ensuing subsection. The section ends with a formal lemma that the described two-step procedure solves the full optimization problem.

3.1 Domestic Optimization Problem

Domestic Agents We describe the domestic optimization problem of a representative agent in country i for given external allocations (m^i, M^i), domestic aggregate allocations X^i, domestic policy variables ζ^i and exogenous state variables Z^i. For ease of notation, we will suppress the vector Z^i of exogenous state variables in the functions that we define in the following, though we note that all equilibrium objects depend on the exogenous vector Z^i.

We define the reduced-form utility of the representative agent as

$$v^i\left(m^i; M^i, X^i, \zeta^i\right) = \max_{x^i} U^i\left(x^i\right) \quad \text{s.t.} \quad f^i\left(m^i, x^i, M^i, X^i, \zeta^i, Z^i\right) \le 0 \tag{5}$$

Denoting the shadow prices on the domestic constraints by the row vector λ^i_d which contains a shadow price for each element of the constraint set f^i, the collection of domestic optimality conditions of a representative agent is

$$U^i_x = f^{i\,T}_x \lambda^{i\,T}_d \tag{6}$$

where U_x denotes a column vector of partial derivatives of the utility function with respect to x^i, and f^i_x is the Jacobian of derivatives of f^i with respect to x^i and is a matrix of the size of $f^i(\cdot)$ times the size of x^i.

Domestic Policymaker For a given aggregate external allocation M^i, a domestic policymaker in economy i chooses the optimal domestic policy measures ζ^i and aggregate choice variables X^i where she internalizes the consistency conditions $x^i = X^i$ and $m^i = M^i$ as well as the implementability constraint (6). The planner's problem is

$$\max_{X^i, \zeta^i, \lambda^i_d} U^i\left(X^i\right) \qquad \text{s.t.} \qquad f^i\left(M^i, X^i, M^i, X^i, \zeta^i, Z^i\right) \le 0, \;\; (6) \tag{7}$$

We assign the row vectors of shadow prices Λ^i_d to the collection of domestic constraints f^i and μ^i_d to the collection of domestic implementability constraints. The solution to this problem defines the optimal domestic policy measures $\zeta^i(M^i)$ and aggregate domestic choice variables $X^i(M^i)$.

Optimal Domestic Allocation For a given aggregate external allocation M^i, the optimal domestic allocation in country i consists of a consistent domestic allocation $x^i = X^i$ and domestic policy measures ζ^i that solve the domestic optimization problem (7) of a domestic policymaker and, by implication, the domestic optimization problem (5) of private agents in country i since the policymaker observes the implementability constraint (6).

Definition 2 (Reduced-Form Utility) *We define the reduced-form utility function of a representative agent in economy i for a given pair* (m^i, M^i) *by*

$$V^i\left(m^i, M^i\right) = v^i\left(m^i, M^i, X^i\left(M^i\right), \zeta^i\left(M^i\right)\right) \tag{8}$$

The reduced-form utility function $V^i(m^i, M^i)$ is also defined for off-equilibrium allocations in which m^i and M^i differ since individual agents are in principle free to choose any allocation of m^i, but in equilibrium, however, $m^i = M^i$ will hold.

For the remainder of our analysis, we will focus on the case where the partial derivatives of this reduced-form utility function satisfy $V^i_m > 0$ and $V^i_m + V^i_M > 0$ $\forall i$: ceteris paribus, a marginal increase in individual imports m^i_t or a simultaneous marginal increase in both individual and aggregate imports $m^i = M^i$ increases the welfare of a representative consumer. These are fairly mild assumptions that hold for the vast majority of open economy macro models, including our baseline model.

For concreteness, the reduced-form utility function in our baseline example 1 is $V^i(m^i, M^i) = \sum_t \beta^t u(y^i_t + m^i_t)$, satisfying the above marginal utility conditions since $V^i_{m,t} = V^i_{m,t} + V^i_{M,t} = \beta^t u'(c^i_t) > 0 \forall i, t$.

The reduced-form utility function $V^i(m^i, M^i)$ contains all the information that is required to describe external allocations and the global equilibrium.

3.2 External Allocations

Representative Agent Given the reduced-form utility function $V^i(m^i, M^i)$, an international price vector Q, a vector of tax instruments τ^i on external transactions, initial external wealth w^i_0, transfer T^i and aggregate external allocations M^i, the second-step optimization problem of a representative agent in country i defines the agent's reduced-form import demand function

$$m^i\left(Q, \tau^i, w^i_0, T^i, M^i\right) = \arg\max_{m^i} V^i\left(m^i, M^i\right) \quad \text{s.t.} \quad (2) \tag{9}$$

Assigning the scalar shadow price λ^i_e to the external budget constraint (2), the associated optimality conditions

$$\left(1 - \tau^i\right)^T V^i_m = \lambda^i_e Q^T \tag{10}$$

describe the excess demand for each component of the import vector m^i of the representative agent as a function of the vector of world market price Q, where the tax vector $(1-\tau^i)$ pre-multiplies the column vector V_m^i in an element-by-element fashion.

We define the aggregate reduced-form import demand function $M^i(Q,\tau^i,w_0^i)$ as the fixed point of the representative agent's reduced-form import demand function $M^i = m^i\left(Q,\tau^i,w_0^i,\frac{\tau^i Q}{1-\tau^i}\cdot M^i,M^i\right)$ that satisfies the government budget constraint $T^i = \frac{\tau^i Q}{1-\tau^i}\cdot M^i$. In some of our applications below, we will assume that $w_0^i = 0$ and suppress the last argument so the function is $M^i(Q,\tau^i)$.

Laissez-Faire Equilibrium We define the allocation that prevails when $\tau^i = 0$, $T^i = 0\ \forall i$ as the laissez-faire equilibrium. We assume that domestic policymakers use their domestic policy instruments ζ^i optimally as described in problem (7).

Competitive Planner Next we consider how a policymaker in country i optimally determines the policy instruments τ^i on external transactions if she acts competitively on the world market in the sense of taking the price vector Q as given. We term this interchangably a *competitive policymaker* or *competitive planner*. There are several potential interpretations for such behavior: First, country i may be a small economy with $\omega^i \approx 0$ so that it is not possible for the planner to affect world market prices. Secondly, the policymaker may choose her optimal allocations while acting with benign neglect towards international markets. This may be the consequence of an explicitly domestic objective of the policymaker prescribed by domestic law, because the policymaker observes a multilateral agreement to abstain from monopolistic behavior and disregard world-wide terms-of-trade effects, or because of enlightened economics.[7] We will analyze the behavior of a monopolistic policymaker who internalizes her market power over world market prices Q in Section 5, which also discusses how to distinguish between monopolistic and competitive behavior of policymakers.

Since the planner has a full set of policy instruments to control M^i, we can solve directly for the planner's optimal allocations and set the instruments τ^i to implement the desired allocation.

A competitive planner who faces the reduced-form utility function $V^i(m^i,M^i)$ and initial external wealth w_0^i solves

$$\max_{M^i} V^i\left(M^i,M^i\right) \quad \text{s.t.} \quad Q\cdot M^i \leq w_0^i \tag{11}$$

[7] For example, the US Federal Reserve claims to follow a policy of acting with benign neglect towards external considerations such as exchange rates, as articulated by Bernanke (2013). Similarly, the G-7 Ministers and Governors proclaimed in a Statement after their March 2013 summit that "we reaffirm that our fiscal and monetary policies have been and will remain oriented towards meeting our respective domestic objectives using domestic instruments, and that we will not target exchange rates" (G-7, 2013).

Assigning a shadow price Λ_e^i to the planner's external budget constraint, the optimality condition is

$$V_m^i + V_M^i = \Lambda_e^i Q^T \tag{12}$$

Lemma 1 (Implementation) *The planner can implement her optimal external allocation by setting the vector of policy instruments*

$$\tau^i = -\left(V_M^i / V_m^i\right)^T \tag{13}$$

where the division V_M^i / V_m^i is performed element-by-element at the optimal allocation.

Proof. Substituting the optimal τ^i from (13) into the optimality condition of private agents (10) yields the planner's optimality condition (12). ■

For given world prices Q and initial wealth w_0^i, the lemma defines a function $\tau^i(Q, w_0^i)$ that implements the optimal external allocation. According to this implementation, the planner does not intervene in time periods/states of nature/goods for which $V_{M,t}^i = 0$, i.e. for which the marginal benefit is fully internalized by private agents. By contrast, if there is an uninternalized benefit to inflows $V_{M,t}^i > 0$, then $\tau_t^i < 0$ so the planner subsidizes m_t^i, and vice versa for negative externalities $V_{M,t}^i < 0$. In some of our applications below, we will assume $w_0^i = 0$ and drop the second argument from the function $\tau^i(Q)$.

To conclude the solution to the general problem described in this section, we observe formally that the two-stage procedure that we followed to separate the problem into a domestic and external optimization problem indeed solves the general problem:

Lemma 2 (Separability) *The allocation that solves the two separate stages of the domestic and external optimization problem described by (7) and (11) solves the combined planning problem.*

Proof. See appendix A.1. ■

Since the planner has a full set of instruments to determine the optimal external allocation, the optimal domestic allocation can be determined without considering the interactions with the external allocation – there is no need to distort the domestic allocation in order to achieve external goals. Formally, the separability results from the fact that the external implementability constraint on the planner is slack and, given M^i, can be ignored by the planner when solving for the optimal domestic allocations. We will show in section 6 that this no longer holds when the planner faces an imperfect set of external policy instruments. In that case, the planner has an incentive to use domestic policies ζ^i in order to affect external allocations M^i and therefore the planner's domestic optimization problem is no longer described by problem (7).

One practical implication of the lemma is that the two tasks of implementing the optimal domestic and external allocations of the economy could be performed by two separate agencies, and the agency responsible for domestic policy does not need to coordinate with the agency that sets the country's external policy instruments.

Lemma 3 (Indeterminacy of Implementation) *There is a continuum of alternative implementations for the external allocation of a country i described by lemma 1, in which its policy instruments are re-scaled by a positive constant $k^i > 0$ s.t. $(1-\tilde{\tau}^i) = k^i(1-\tau^i)$.*

Proof. The re-scaling of policy instruments does not affect the external budget constraint of the economy since revenue is rebated lump-sum. It simply rescales the shadow price Λ_e^i in the optimality condition (12) by $1/k^i$. Therefore the old allocation still satisfies all the optimality conditions of the economy. ■

The intuition is that the incentive of a representative agent to shift consumption across time/states of nature/goods only depends on the relative price of goods in the vector m^i. Multiplying all prices by a constant and changing initial net worth by the corresponding amount is equivalent to changing the numeraire.

By the same token, if there exists a scalar $h^i \in (-1, \infty)$ s.t. $V_M^i = h^i V_m^i$, then it is not necessary for the country i planner to intervene since the vector of policy instruments $\tilde{\tau}^i = 0$ will implement the same equilibrium as the vector $\tau^i = -\left(V_M^i / V_m^i\right)^T$. This can easily be verified by setting $k^i = \frac{1}{1+h^i}$ and applying lemma 3. In the following, we will assume that $\nexists h^i$ that satisfies $V_M^i = h^i V_m^i$ when we speak of a country that exhibits externalities.

3.3 Welfare Properties of Equilibrium

We now turn to the welfare properties of the described global equilibrium. We start with a definition:

Definition 3 (Pareto Efficient Allocations) *A Pareto efficient global allocation is a feasible global allocation $\left(M^i, X^i, \zeta^i\right)_{i=1}^N$ such that there does not exist $\nexists$ another feasible allocation $(\tilde{M}^i, \tilde{X}^i, \tilde{\zeta}^i)_{i=1}^N$ that makes at least one country better off such that $U^i(\tilde{X}) \geq U^i(X)\, \forall i$ with at least one strict inequality.*

Given this definition, we find:

Proposition 1 (Efficiency of Global Equilibrium) *The global competitive equilibrium allocation as per Definition 1 is Pareto efficient.*

Proof. An allocation is Pareto efficient if it maximizes the weighted sum of welfare of all countries for some vector of welfare weights $\left\{\phi^i \geq 0\right\}_{i=1}^N$ subject to the global resource constraint and the domestic constraints of each country i, i.e. if it solves

$$\max_{\left\{M^i,X^i,\zeta^i\right\}_i} \sum_i \phi^i \omega^i U^i\left(X^i\right) \qquad \text{s.t.} \qquad \begin{array}{l} \sum_i \omega^i M^i = 0, \ \ (6), \\ f^i\left(M^i, M^i, X^i, X^i, \zeta^i, Z^i\right) \leq 0 \ \ \forall i \end{array}$$

By the definition of $V^i\left(m^i, M^i\right)$, we can restate this problem in terms of reduced-form utilities the optimal external allocations $\left(M^i\right)_{i=1}^N$,

$$\max_{\{M^i\}_i} \sum_i \phi^i \omega^i V^i\left(M^i, M^i\right) \qquad \text{s.t.} \qquad \sum_i \omega^i M^i = 0$$

Assigning the shadow price ν to the vector of resource constraints, the optimality condition of the global planner is

$$\phi^i\left(V_m^i + V_M^i\right) = \nu^T \quad \forall i$$

Any global competitive equilibrium that satisfies Definition 1 also satisfies these optimality conditions if we assign the shadow price $\nu = Q$ and the welfare weights $\phi^i = 1/\Lambda_e^i$ where Λ_e^i is the shadow price on the external budget constraints of the external optimization problem (11) of country i. Therefore any such equilibrium is Pareto efficient. ■

The proposition is a version of the first welfare theorem. Since the domestic competitive planner in each country i has a complete set of external tax instruments τ^i, she can fully determine the efficient excess demand M^i of country i given the world market price Q. If the planner acts competitively in determining M^i, then all the conditions of the first welfare theorem apply and the resulting competitive equilibrium is Pareto efficient. Given that the planner has internalized all domestic externalities, the excess demand M^i of the country correctly reflects the country's social marginal valuation of capital flows. The marginal rates of substitution of all domestic planners are equated across countries, and the resulting equilibrium is Pareto efficient.

Inefficiency of Laissez-Faire Equilibrium A straightforward corollary to Proposition 1 is that the laissez-faire equilibrium is generally not Pareto efficient if there are countries subject to externalities from international capital flows with $V_M^i \neq 0$.

Moving from the global laissez-faire equilibrium to the equilibrium with efficient interventions τ^i as characterized in Lemma 1 does create spillover effects since global prices Q and quantities $\left(M^i\right)_{i=1}^N$ will adjust. Even if these spillover effects are large, they are not a sign of Pareto inefficiency. They constitute pecuniary externalities that are mediated by a complete market for M^i. As such, they generate redistributions between borrowing (importing) and lending (exporting) countries, but Pareto efficiency is independent of such redistributive considerations.

Tatonnement and Arms Race The equilibrium adjustment (tatonnement) process when the optimal interventions τ^i are imposed may sometimes involve dynamics that look like an arms race. For example, assume that several countries experience negative externalities $V^i_{M,t} < 0$ from capital inflows M^i and that the absolute magnitude of these externalities increases in a convex fashion $V^i_{MM,t} < 0$ in period t. An exogenous shock that makes one country increase its optimal degree of intervention, leads to greater capital flows to all other countries. This increases the externalities in other countries and induces them to respond with greater intervention, which in turn deflects capital back into the original country, triggering further intervention there, and so on.

Such dynamics may give the appearance of an arms race but are nonetheless efficient. As long as the conditions of Proposition 1 are satisfied, this "arms race" is simply the natural mechanism through which an efficient equilibrium is achieved. In the described example, each successive round of spillovers will be smaller and the degree of intervention will ultimately converge towards its efficient levels, which involves greater intervention by all affected countries.

3.4 Pareto-Improving Intervention

If the objective of a global planner is not only to achieve Pareto efficiency but the more stringent standard of achieving a Pareto improvement compared to the laissez-faire allocation, then the imposition of policy instruments $(\tau^i)_{i=1}^N$ generally needs to be accompanied by cross-border transfers that compensate the countries that lose from changes in world prices/interest rates:

Proposition 2 (Pareto-Improving Intervention with Transfers) *Starting from the laissez faire equilibrium, a global planner who identifies domestic externalities $V^i_M \neq 0$ can achieve a Pareto improvement by setting the interventions $\tau^i = -V^i_M / V^i_m$ $\forall i$ and providing compensatory international transfers $\hat{T}^i$ that satisfy $\sum_i \hat{T}^i = 0$.*

Proof. Denote the net imports and world prices in the laissez faire equilibrium by $(M^{i,LF})$ and Q^{LF} and in the global planner's equilibrium that results from imposing (τ^i) and transfers $(\hat{T}^i)$ by $(M^{i,GP})$ and Q^{GP}. Assume the planner provides cross-border transfers

$$\hat{T}^i = Q^{GP} \cdot \left(M^{i,LF} - M^{i,GP} \right)$$

These transfers satisfy $\sum \hat{T}^i = 0$ since both sets of allocations (LF and GP) clear markets. Furthermore, given these transfers, consumers in each country i can still afford the allocation that prevailed in the laissez faire equilibrium. For non-zero interventions (τ^i), the allocation differs from the laissez faire equilibrium according to the optimality condition (10). Given that the old allocation is still feasible but is not chosen, revealed preference implies that every country is better off under the new allocation. ■

In an international context, compensatory transfers may be difficult to implement. As an alternative, we show that a planner who can coordinate the policy instruments of both source and destination countries for M^i can correct the domestic externalities of individual economies while holding world prices and interest rates constant so that no wealth effects arise. As a result, the global planner's intervention generates a global Pareto improvement at a first-order approximation.

The following lemma demonstrates how a global planner can manipulate world prices by simultaneously adjusting the instruments in all countries worldwide; then we show how this mechanism can be used to hold world prices fixed so as to avoid redistributive effects when correcting for externalities in a given country.

Lemma 4 *Consider a global competitive equilibrium with an external allocation $(M^j)_j$, external policy instruments $(\tau^j)_j$ and world prices Q. A global planner can change world prices by dQ while keeping the external allocations of all countries constant by moving the policy instruments in each country $j = 1...N$ by moving*

$$\left(d\tau^j\right)^T = -\left(M_\tau^j\right)^{-1} M_Q^j \left(dQ\right)^T \tag{14}$$

Proof. We set the total differential of the net import demand function $M^j\left(Q, \tau^j, w_0^j\right)$ of country j with respect to world prices and policy instruments to zero,

$$dM^j = M_Q^j \left(dQ\right)^T + M_\tau^j \left(d\tau^j\right)^T = 0$$

and rearrange to obtain equation (14). ■

In the following proposition, we assume an exogenous increase in the negative externalities $dV_M^i < 0$ to a country i. If the country did not respond to this shock, its welfare would decline by $dV_M^i \cdot M^i$. If the country responds by unilaterally increasing its policy instruments by $d\tau^i = -dV_M^i / V_m^i > 0$ as suggested by lemma 1, world market prices Q would change, and some countries would gain whereas others would lose from the resulting redistribution. The change in world prices and the redistribution can be avoided using the following policy:

Proposition 3 (Pareto-Improving Intervention, No Transfers) *Assume an exogenous marginal increase in the externalities of country i that calls for an adjustment $d\tau^i$ in the optimal unilateral taxes. A global planner can correct for the increase in externalities while keeping world prices constant $dQ = 0$ to avoid income and wealth effects by adjusting*

$$\begin{aligned} \left(d\tilde{\tau}^j\right)^T &= -\omega^i \left(M_\tau^i\right)^{-1} M_Q^j \left(M_Q\right)^{-1} M_\tau^i \left(d\tau^i\right)^T \\ \textit{and} \quad \left(d\tilde{\tau}_t^i\right)^T &= \left[I - \omega^i \left(M_\tau^i\right)^{-1} M_Q^i \left(M_Q\right)^{-1} M_\tau^i\right] \left(d\tau^i\right)^T \end{aligned}$$

where we define $M_Q \equiv \sum_j \omega^j M_Q^j$. In the resulting equilibrium, net imports $(M^j)_j$ are marginally altered but world prices are unchanged. By the envelope theorem, welfare is unchanged at a first-order approximation.

Proof. If the domestic planner implemented the unilaterally optimal change $d\tau^i$, then world prices would move by $(dQ)^T = -\omega^i (M_Q)^{-1} M_\tau^i (d\tau^i)^T$. According to Lemma 4, the move in world prices can be undone if the taxes of all countries $j = 1...N$ are simultaneously adjusted by $-(M_\tau^j)^{-1} M_Q^j (dQ)^T$, which delivers the first equation of the proposition. The second equation is obtained by adding the optimal unilateral change in intervention $d\tau^i$ plus the adjustment given by the first equation with $j = i$. In the resulting equilibrium, the change in the externality $d\tau^i$ is accounted for but world market prices are unchanged. Furthermore, by the envelope theorem, the change in welfare that results from a marginal change in M^j is[8]

$$dV^j\Big|_{dQ=0} = \left(V_m^j + V_M^j\right)^T \cdot dM^j = 0$$

■

The intuition of this intervention is best captured by the following example:

Example 3.1 (Pareto-Improving Intervention, Symmetric Countries) Consider a word economy that consists of N open economies as described in the baseline model of example 2.1 that are identical except in their size ω^i. Since the economies are identical, observe that $M_Q^j(M_Q) = I\ \forall j$. Assume country i experiences a marginal increase in some externality that calls for a change $d\tau^i$ in its optimal unilateral external policy instruments. A planner would achieve a Pareto improvement at a first-order approximation by instead setting

$$\begin{aligned} d\tilde{\tau}^i &= \left(1 - \omega^i\right) d\tau^i \\ d\tilde{\tau}^j &= \omega^i d\tau^i \end{aligned}$$

As this example illustrates, a planner who aims for a Pareto improving intervention would share the burden of adjusting policy instruments between country i and the rest-of-the-world according to their relative size. The larger country i, the greater the impact of its interventions on world prices and therefore the more of the intervention the planner would shift to other countries so as to keep world prices Q constant and avoid redistributions. In the extreme case that i is a small open economy, the planner would only intervene in country i since its impact on world prices is negligible. If the countries differ in other aspects than size, the terms M_Q^i and M_τ^i in proposition 3 account for their differential responses to changes in world prices and policy instruments.

[8] For non-infinitesimal changes in τ^i, changes in net imports ΔM^j have second-order effects on welfare (i.e. effects that are negligible for infinitesimal changes but growing in the square of ΔM^j) even if world prices are held constant. Under certain conditions, e.g. if there are only two types of countries in the world economy, a global planner can undo these second-order effects via further adjustments in the world prices Q.

4 Examples and Applications

This section investigates several examples of externalities that have been used in the literature and in policy circles to motivate policy interventions that affect external allocations and that are therefore relevant for our analysis of spillover effects. We start with two simple examples of learning externalities that are triggered either by exporting or by producing and in which capital account interventions represent first-best and second-best policy instruments, respectively. Then we analyze aggregate demand externalities that may occur if a country experiences a liquidity trap.

Even if one is skeptical of the existence of some of the described externalities, these are important question to analyze since policymakers have explicitly invoked such externalities when they engaged in capital account interventions, exemplified by Brazilian finance minister Guido Mantega (see Wheatley and Garnham, 2010).

4.1 Learning-by-Exporting Externalities

Our first example, chosen for its simplicity of exposition, are learning-by-exporting externalities.[9] Assume a representative agent in a canonical open economy i that behaves as in our baseline model of capital flows (example 2.1), except that the endowment income y^i_{t+1} is a function $\varphi_t(\cdot)$ of the economy's aggregate net imports M^i_t that satisfies $\varphi_t(0) = 0$ and that is continuous and decreasing $\varphi'_t(M_t) \leq 0$ to capture that higher net exports increase growth,

$$y^i_{t+1} = y^i_t + \varphi_t\left(M^i_t\right) \tag{15}$$

The reduced-form utility of a representative agent in country i is

$$V^i\left(m^i, M^i\right) = \sum_t \beta^t u\left(y^i_0 + \sum_{s=0}^{t-1} \varphi_s\left(M^i_s\right) + m^i_t\right)$$

with marginal utility of private and aggregate capital inflows of $V^i_{m,t} = \beta^t u'\left(C^i_t\right)$ and $V^i_{M,t} = \varphi'_t\left(M^i_t\right)\beta^t v_{t+1}$ where $v^i_{t+1} = \sum_{s=t+1}^{\infty} \beta^{s-t} u'\left(C^i_s\right)$ is the PDV of one extra unit of output growth at time $t+1$, capturing the growth externalities from exporting. Following lemma 1, a planner can implement the socially efficient allocation in economy i by imposing capital controls

$$\tau^i_t = -V^i_{M,t}/V^i_{m,t} = -\frac{\varphi'_t\left(M^i_t\right) v^i_{t+1}}{u'\left(C^i_t\right)} \geq 0 \tag{16}$$

[9] There is a considerable theoretical literature that postulates that such effects are important for developing countries in the phase of industrialization. See for example Rodrik (2008) and Korinek and Servén (2010). In the empirical literature there have been some studies that document the existence of learning externalities, whereas others are more skeptical. For a survey see e.g. Giles and Williams (2000).

The planner subsidizes exports/capital outflows and taxes imports/capital inflows in periods in which net exports generate positive externalities.

It is typically argued that learning externalities are only relevant during transition periods in developing economies (see e.g. Rodrik, 2008). In that case, the externality term $\varphi_t'(M_t^i)$ would at first be negative and would gradually converge to zero.

In the described framework, capital control are the first-best policy tool to internalize learning-by-exporting externalities, since they directly target net saving and hence the trade balance of the economy.

Since our model of learning-by-exporting externalities nests into the general model of section 2, it is a straightforward application of proposition 1 that the intervention of a competitive planner to internalize such externalities leads to a Pareto efficient outcome from a global perspective.

4.2 Learning-by-Doing Externalities

Capital account intervention may also serve as a second-best instrument in an economy where it would be desirable to use domestic policy measures to correct a distortion but such measures are not available.

The following example show how capital controls may serve to internalize learning-by-doing externalities in a production economy in which productivity growth is an increasing function of employment. The first-best policy instrument in such a setting is a subsidy to employment. However, if such an instrument is not available (for example, because of a lack of fiscal resources, a large informal sector, or the risk of corruption), it may be optimal to resort to capital controls as a second-best instrument to improve welfare.

Assume that the output of a representative worker in economy i is given by $y_t^i = A_t^i \ell_t^i$, where labor ℓ_t^i imposes a convex disutility $d(\ell_t^i)$ on workers. We capture learning-by-doing externalities by assuming that productivity growth A_t^i in the economy is a continuous and increasing function of aggregate employment $\psi_t(L_t^i)$ that satisfies $\psi_t'(\cdot) \geq 0$ so that

$$A_{t+1}^i = A_t^i + \psi_t\left(L_t^i\right) = A_0^i + \sum_{s=0}^{t} \psi_s\left(L_s^i\right) \tag{17}$$

In the described economy, the first-best policy instrument to internalize such learning effects would be a subsidy s_t^i to wage earnings in the amount of $s_t^i = \psi_t'(L_t^i)\, v_{A,t+1}/[u'(c_t^i)\, A_t^i]$ where $v_{A,t+1} = \sum_{s=t+1}^{\infty} \beta^{s-t} u'(c_s^i)\, L_s^i$ is the PDV of one unit of productivity growth starting period $t+1$.

In the absence of a policy instrument to target the labor wedge, a planner faces the implementability constraint

$$A_t^i u'\left(A_t^i L_t^i + M_t^i\right) = d'\left(L_t^i\right) \tag{18}$$

which reflects the optimal labor supply condition of individual workers. Observe that reducing M_t^i in this constraint is akin to a negative wealth effect and increases the marginal utility of consumption, which in turn serves as a second-best instrument to raise L_t^i and trigger learning-by-doing externalities.

Accounting for this implementability constraint and imposing the consistency condition $\ell_t^i = L_t^i$, a constrained planner recognizes that the reduced-form utility of the economy is

$$V\left(m^i, M^i\right) = \max_{L_t^i} \sum_t \beta^t \left\{u\left(A_t^i L_t^i + m_t^i\right) - d\left(L_t^i\right)\right\} \quad \text{s.t.} \quad (17), (18)$$

with marginal utility of private and aggregate capital inflows of $V_{m,t}^i = \beta^t u'\left(C_t^i\right)$ and $V_{M,t}^i = -\lambda_t^i \beta^t A_t^i u''\left(C_t^i\right) < 0$ where λ_t is the shadow price on the implementability constraint (18) and is given by

$$\lambda_t^i = \frac{\psi_t'\left(L_t^i\right) v_{A,t+1}^i}{d''\left(L_t^i\right) - \left(A_t^i\right)^2 u''\left(C_t^i\right)} > 0$$

In this expression, the positive learning externalities (in the numerator) are scaled by a term that reflects how strongly labor supply responds to changes in consumption (in the denominator).[10] If the economy has outgrown its learning externalities, the term drops to zero.

Following lemma 1, the planner can implement this second-best solution by imposing capital controls of[11]

$$\tau_t^i = -\frac{\lambda_t A_t^i u''\left(C_t^i\right)}{u'\left(C_t^i\right)} = \frac{\psi_t'\left(L_t^i\right) v_{A,t+1}}{d'\left(L_t^i\right)\left(1 + \frac{\eta_L}{\sigma_C}\right)} \tag{19}$$

This control reduces capital inflows and stimulates domestic production to benefit from greater learning-by-doing externalities. The numerator in the expression is analogous to the optimal capital control (16) under learning-by-exporting. In the

[10] Given that there are no first-best policy instruments available, the PDV of one unit of productivity growth $\nu_{A,t}^i$ also includes the effects of higher productivity on future labor supply decisions: on the one hand, higher productivity increases incentives to work, on the other hand it makes the agent richer and reduces the incentive to work via a wealth effect. The two effects are captured by the two expressions in square brackets,

$$v_{A,t+1}^i = \sum_{s=t+1}^{\infty} \beta^{s-t} \left\{u'\left(C_s^i\right) L_s^i + \lambda_s^i \left[u'\left(C_s^i\right) + A_s^i u''\left(C_s^i\right) L_s^i\right]\right\}$$

[11] The right-hand side of the expression can be obtained by substituting for λ_t^i and observing that $A_t^i u'\left(C_t^i\right) = d'\left(L_t^i\right)$ and

$$\frac{A_t^i u''\left(C_t^i\right)}{d''\left(L_t^i\right) - \left(A_t^i\right)^2 u''\left(C_t^i\right)} = -\frac{1}{A_t^i\left(1 + \frac{\eta_L}{\sigma_C}\right)}$$

denominator term, η_L and σ_C are the Frisch elasticity of labor supply and the intertemporal elasticity of substitution: the second-best intervention is more desirable the more responsive the marginal disutility of labor (high η_L) and the more responsive the marginal utility of consumption (low σ_C).

Proposition 1 implies, as in the previous case, that the application of second-best capital controls lead to a globally Pareto efficient outcome. Even though capital controls (19) are only second-best instruments, they are chosen to precisely equate the marginal social benefit from indirectly triggering the LBD-externality to their marginal social cost, given the restriction on the set of available instruments. Reducing domestic consumption by running a trade surplus is the only way available to induce domestic agents to work harder. Since a global planner does not have superior instruments, he cannot do better than this and chooses an identical allocation. The global efficiency implications of second-best capital controls are no different from other reasons to implement capital controls.

4.3 Aggregate Demand Externalities at the ZLB

Next we study the multilateral implications of capital controls to counter aggregate demand externalities at the zero lower bound (ZLB) on nominal interest rates. We develop a stylized framework that captures the essential nature of such externalities in the spirit of Krugman (1998) and Eggertsson and Woodford (2003), adapted to an open economy framework as in Jeanne (2009).[12]

Assume that a representative consumer in country i derives utility from consuming c_t^i units of a composite final good and experiences disutility from providing ℓ_t^i units of labor. Collecting the two time series in the vectors c^i and ℓ^i, we denote

$$U^i\left(c^i,\ell^i\right)=\sum\beta^t\left[u\left(c_t^i\right)-d\left(\ell_t^i\right)\right]$$

As is common in the New Keynesian literature, we assume that there is a continuum $z\in[0,1]$ of monopolistic intermediate goods producers who are collectively owned by consumers and who each hire labor to produce an intermediate good of variety z according to the linear function $y_t^{iz}=\ell_t^{iz}$, where labor market clearing requires $\int\ell_t^{iz}dz=\ell_t^i$. All the varieties are combined in a CES production function to produce final output

$$y_t^i=\left(\int_0^1\left(y_t^{iz}\right)^{\frac{\varepsilon-1}{\varepsilon}}dz\right)^{\frac{\varepsilon}{\varepsilon-1}}$$

where the elasticity of substitution is $\varepsilon>1$. We assume that the monopoly wedge arising from monopolistic competition is corrected by a proportional subsidy $\frac{1}{\varepsilon-1}$ that is financed by a lump-sum tax on producers. This implies that the wage income

[12] A complementary analysis of prudential (as opposed to stimulative) capital controls due to aggregate demand externalities at the ZLB is provided in Section 5.2 of Farhi and Werning (2013) in a small open economy setting.

and profits of the representative agent equal final output, which in turn equals labor supply $w_t\ell_t^i + \pi_t^i = y_t^i = \ell_t^i$. In real terms and vector notation, the period budget constraints of a representative agent and the external budget constraint are given by

$$c^i = w\ell^i + \pi^i + m^i = y^i + m^i \qquad \text{and} \qquad \frac{Q}{1-\tau^i} \cdot m^i - T^i \leq w_0^i$$

The condition for the optimal labor supply of the representative agent is

$$d'\left(\ell_t^i\right) = w_t^i u'(c_t^i)$$

We assume that the nominal price of one unit of consumption good follows an exogenous path $P^i = (1, P_2^i, P_3^i, ...)$ that is credibly enforced by a central bank (see Korinek and Simsek, 2014, for further motivation). This assumption precludes the central bank from committing to a future monetary expansion or future inflation in order to stimulate output in the present period.[13] The corresponding gross rate of inflation is given by $\Pi_{t+1}^i = P_{t+1}^i / P_t^i$ or by $\Pi^i = P/L\left(P\right)$ in vector notation with lag operater $L\left(\cdot\right)$. One example is a fixed inflation target $\Pi_{t+1}^i = \bar{\Pi}^i \; \forall \; t$.

Combining the ZLB constraint on the nominal interest rate $i_{t+1}^i = R_{t+1}\Pi_{t+1} - 1 \geq 0$ with the aggregate Euler equation to substitute for R_{t+1}, the ZLB in period t imposes a ceiling on aggregate period t consumption,

$$u'\left(C_t^i\right) \geq \frac{\beta}{\Pi_{t+1}^i} u'\left(C_{t+1}^i\right) \quad \forall t \tag{20}$$

Intuitively, a binding ZLB implies that consumption is too expensive in period t compared to consumption in the following period, limiting aggregate demand in period t to the level indicated by the constraint.

In the laissez-faire equilibrium, this constraint is satisfied with strict inequality if world aggregate demand for bonds and by extension the world interest rate is sufficiently high, i.e. if $R_{t+1} \geq 1/\Pi_{t+1}^i$. Then the market-clearing wage $W_t^i = 1$ will prevail and output Y_t^i is at its efficient level determined by the optimality condition $u'\left(C_t^i\right) = d'\left(L_t^i\right)$. We call this output level potential output Y_t^{i*}.

If worldwide aggregate demand declines and the world real interest rate hits the threshold $R_{t+1} = 1/\Pi_{t+1}^i$, then the domestic interest rate cannot fall any further. Instead, any increase in the world supply of bonds will flow to economy i, which pays a real return of $1/\Pi_{t+1}^i$ by the feature of offering liabilities with zero nominal interest rate. Given the high return on nominal bonds, consumers in economy i find that today's consumption goods are too expensive compared to tomorrow's consumption goods and consumers reduce their demand for today's consumption goods. Output is demand-determined, so Y_t^i falls below potential output Y_t^{i*} in order to satisfy equation

[13] It is well known in the New Keynesian literature that the problems associated with the zero lower bound could be avoided if the monetary authority was able to commit to a higher inflation rate. See e.g. Eggertsson and Woodford (2003).

(20). The wage also falls below its efficient level $W_t^i < 1$. This situation captures the essential characteristic of a liquidity trap: at the prevailing nominal interest rate of zero, consumers do not have sufficient demand to absorb both domestic output and the capital inflow M_t^i. Intermediate producers cannot reduce their prices and need to adjust output so that demand equals supply.

At the ZLB, a planner finds it optimal to erect barriers against capital inflows or encourage capital outflows in order to stimulate domestic aggregate demand. We substitute the domestic period budget constraint and the consistency condition $x^i = X^i$ and denote the reduced-form utility maximization problem of a planner in country i according to definition 2 by

$$V\left(m^i, M^i\right) = \max_{L^i} \sum \beta^t \left[u\left(L_t^i + m_t^i\right) - d\left(L_t^i\right)\right] \quad \text{s.t.} \qquad \begin{array}{l} u'\left(L_t^i + M_t^i\right) \geq \dfrac{\beta}{\Pi_{t+1}^i} u'\left(L_{t+1}^i + M_{t+1}^i\right) \forall t \\ d'\left(L_t^i\right) \leq u'\left(L_t^i + M_t^i\right) \forall t \end{array}$$

where the second line captures the implementability constraint that ensures that the central bank cannot commit to future monetary expansion to induce workers to produce more, as we assumed earlier.

Assigning the shadow prices $\beta^t \mu_t$ and $\beta^t \gamma_t$ to the two constraints, the associated optimality conditions are

$$FOC\left(L_t^i\right): u'\left(C_t^i\right) - d'\left(L_t^i\right) + \left[\mu_t - \mu_{t-1}/\Pi_t^i\right] u''\left(C_t^i\right) - \gamma_t \left[d''\left(L_t^i\right) - u''\left(C_t^i\right)\right] = 0$$

When the ZLB constraint is loose, the shadow prices μ_t and γ_t are zero. If the ZLB is binding in period t, then $\mu_t = \frac{u'\left(C_t^i\right) - d'\left(L_t^i\right)}{-u''\left(C_t^i\right)} > 0$ reflects the labor wedge in the economy created by the lack of demand and the second constraint is trivially satisfied so $\gamma_t = 0$. If the ZLB is loose in the ensuing period $t+1$, then the planner would like to commit to stimulate output in that period as captured by the term $-\mu_t u''\left(C_{t+1}^i\right)/\Pi_{t+1}^i$ so as to relax the ZLB constraint at date t, but we imposed the second constraint to reflect that the planner cannot commit to do this. Therefore $u'\left(C_{t+1}^i\right) = d'\left(L_{t+1}^i\right)$ in that period and the shadow price γ_{t+1} adjusts so that the optimality condition is satisfied $\gamma_{t+1} = \frac{-\mu_t u''\left(C_{t+1}^i\right)/\Pi_{t+1}^i}{d''\left(L_{t+1}^i\right) - u''\left(C_{t+1}^i\right)} > 0$.

The externalities of capital inflows in periods t and $t+1$ in such an economy are given by the partial derivatives

$$V_{m,t}(\cdot) = \beta^t u'\left(C_t^i\right)$$

$$V_{M,t}(\cdot) = \beta^t \left[\mu_t - \mu_{t-1}/\Pi_t^i + \gamma_t\right] u''\left(C_t^i\right)$$

If the economy experiences a liquidity trap in period t but has left the trap in period $t+1$, then $V_{M,t} = \beta^t \mu_t u''\left(C_t^i\right) = -\beta^t \left[u'\left(C_t^i\right) - d'\left(L_t^i\right)\right] < 0$ – the externality from a unit capital inflow is to reduce aggregate demand by one unit, which wastes valuable production opportunities as captured by the positive labor wedge $u'\left(C_t^i\right) - d'\left(L_t^i\right)$. It is optimal to set the policy instrument $\tau_t^i = 1 - \frac{d'\left(L_t^i\right)}{u'\left(C_t^i\right)} > 0$ precisely such as to reflect this social cost, thereby restricting capital inflows and encouraging outflows.

In the following period, it is beneficial to commit to setting $\tau_{t+1}^i < 0$ so as to restrict capital outflows or subsidize capital inflows since

$$V_{M,t+1} = -\beta^{t+1}\mu_t / \Pi_{t+1}^i \left[\frac{d''\left(L_{t+1}^i\right)}{d''\left(L_{t+1}^i\right) - u''\left(C_{t+1}^i\right)}\right] u''\left(C_{t+1}^i\right) > 0$$

This has the effect of raising future consumption, which stimulates consumption during the liquidity trap by relaxing the ZLB constraint (20).[14]

Note that the capital account interventions of a planner in this setting are second-best policies since the first-best policy would be to restore domestic price flexibility to abolish the ZLB constraint. The planner solves the optimal trade-off between foregoing efficient consumption smoothing opportunities by trading with foreigners and wasting profitable production opportunities because of the ZLB.

4.4 Exchange Rate Intervention

[To be written up.]

4.5 Level of Fiscal Spending

Our findings also apply to multilateral considerations about the optimal level of fiscal spending. Such considerations have, for example, been at the center of the political debate on coordinating fiscal stimulus in the aftermath of the Great Recession (see e.g. the G-20 Leaders' Declaration, Nov. 2008; Spilimbergo et al., 2008). We demonstrate how uncoordinated fiscal policy decisions lead to an efficient equilibrium as long as the three conditions underlying our general efficiency proposition are met. In the context of fiscal policy, the most important condition is price-taking behavior since fiscal spending has important terms-of-trade effects. If national policymakers consider these terms-of-trade effects in their optimal policy-making, they are exerting monopoly power and implementing an inefficient level of fiscal spending. The ensuing example will be followed by a more detailed discussion of monopolistic behavior in Section 5.

[To be completed.]

[14] In a time-consistent setting for capital account interventions, the planner would not be able to commit to future policy actions. The intervention during a liquidity trap would still be given by the same expression $V_{M,t} = d'\left(L_t^i\right) - u'\left(C_t^i\right)$, but after the liquidity trap has passed the planner would find $V_{M,t+1} = 0$ and no further intervention would occur.

5 Monopolistic Behavior

5.1 Optimization Problem

Assume next that there is a monopolistic planner in country i with positive mass $\omega^i > 0$ that maximizes the utility of the representative consumer U^i and internalizes that she has market power over world prices Q. We solve the problem of the monopolistic planner under the assumption that the remaining countries $j \neq i$ behave according to the competitive planning setup in section 3.2. The excess demand of the rest-of-the-world excluding country i is then given by the function[15]

$$M^{-i}(Q) = \sum_{j \neq i} \omega^j M^j \left(Q, \tau^j(Q)\right)$$

The function can be inverted to obtain an inverse rest-of-the-world excess demand function $Q^{-i}(M^{-i})$.

A monopolistic planner recognizes that global market clearing requires $\omega^i M^i + M^{-i}(Q) = 0$ and that her external allocations M^i affect world prices since $Q = Q^{-i}(-\omega^i M^i)$. She solves the optimization problem

$$\max_{M^i} V^i \left(M^i, M^i\right) \quad \text{s.t.} \quad Q^{-i}(-\omega^i M^i) \cdot M^i \leq w_0^i$$

leading to the optimality conditions

$$V_m^i + V_M^i = \Lambda_e^i Q^T \left(1 - \mathcal{E}_{Q,M}^i\right) \quad \text{with} \quad \mathcal{E}_{Q,M}^i = \omega^i Q_M^{-i} \left(M^i / Q^T\right) \tag{21}$$

where the column vector $\mathcal{E}_{Q,M}^i$ represents the inverse demand elasticity of imports of the rest of the world and consists of four elements: the country weight ω^i reflects the country's market power in the world market; the Jacobian square matrix $Q_M^{-i} = \partial Q^{-i} / \partial M^{-i}$ captures how much world market prices respond to absorb an additional unit of exports from country i. The column vector M^i post-multiplies this matrix to sum up the marginal revenue accruing to country i from the different goods as a result of monopolistically distorting each good, where the vector M^i is normalized element-by-element by the price vector Q to obtain elasticities.

Lemma 5 (Monopolistic Capital Account Intervention) *The allocation of the monopolistic planner who internalizes her country's market power over world prices can be implemented by setting the vector of external policy instruments to*

$$1 - \hat{\tau}^i = \frac{1 + V_M^i / V_m^i}{1 - \mathcal{E}_{Q,M}^i} \tag{22}$$

where all divisions are performed element-by-element.

[15] Our findings can easily generalized to the case where other countries engage in monopolistic behavior or operate under laissez-faire. The only important assumption for our problem is that each country j has a well-defined and continuous demand function. This rules out, for example, discontinuous trigger strategies.

Proof. The tax vector $\hat{\tau}^i$ ensures that the private optimality condition of consumers (10) replicates the planner's Euler equation (21). ■

Returning to equation (21), a monopolistic planner equates the social marginal benefit of imports $V^i_m + V^i_M$ to the marginal expenditure $Q^T\left(1 - \mathcal{E}^i_{Q,M}\right)$ rather than to the world price Q^T times a factor of proportionality Λ^i_e. She intervenes up to the point where the marginal benefit of manipulating world prices – captured by the elasticity term $\Lambda^i_e Q^T \mathcal{E}^i_{Q,M}$ – equals the marginal cost of giving up profitable consumption opportunities $\Lambda^i_e Q^T - (V^i_m + V^i_M)$. However, giving up profitable consumption opportunities creates a deadweight loss – the planner introduces a distortion to extract monopoly rents from the rest of the global economy. The intervention constitutes a classic inefficient beggar-thy-neighbor policy:

Proposition 4 (Inefficiency of Exerting Market Power) *An equilibrium in which a domestic planner in a country with $\omega^i > 0$ exerts market power is Pareto-inefficient.*

Proof. The result is a straightforward application of proposition 1 that optimality requires competitive behavior. ■

To provide some intuition, assume that the matrix Q^{-i}_M in a country with $\omega^i > 0$ is a diagonal matrix and that there are no domestic externalities so $V^i_M = 0$.[16] The diagonal entries, indexed by t, satisfy $\partial Q^{-i}_t / \partial M^{-i}_t < 0$, reflecting that greater rest-of-the-world imports M^{-i}_t of good t require a lower world price Q_t. If the country is a net importer $M^i_t > 0$ of good t then the elasticity $\mathcal{E}^i_{Q,M,t}$ is negative and the optimal monopolistic tax on imports $\hat{\tau}^i_t > 0$ is positive. Similarly, for goods that are net exports $M^i_t < 0$ the planner reduces the quantity exported by a tax $\hat{\tau}^i_t < 0$. This captures the standard trade-reducing effects of monopolistic interventions.

5.2 Distinguishing Competitive and Monopolistic Behavior

The spillover effects of a policy intervention in external allocations are the same, no matter what the motive for intervention. However, the effects on Pareto efficiency and thus the scope for global cooperation depend crucially on whether policymakers correct for domestic distortions (as described in lemma 1) or exert market power (as described in lemma 5).

Unfortunately there is no general recipe for distinguishing between the two motives for intervention. It is easy for policymakers to invoke market imperfections, domestic objectives or different political preferences to justify an arbitrary set of policy interventions in the name of domestic efficiency, and it is difficult for the international community to disprove them. Specifically, for any reduced-form utility function $V^i(m^i, M^i)$ and monopolistic interventions $\hat{\tau}^i$, there exists an alternative

[16] This is the case, for example, if the reduced-form utility $V\left(m^i, M^i\right)$ is Cobb-Douglas in m^i.

reduced-form utility function $\hat{V}^i(m^i, M^i)$ such that $\hat{\tau}^i$ implements the optimal competitive planner allocation under that utility function,

$$\hat{V}^i(m^i, M^i) = V^i(m^i, M^i) - \hat{\tau}^i \cdot \left(V^i_m M^i\right)$$

The reduced-form utility function $\hat{V}^i(\cdot)$ can in turn be interpreted as deriving from a fundamental utility function $\hat{U}^i(x^i)$ and a set of constraints $\hat{f}^i(\cdot)$ that justify it.

Nonetheless, the direction of optimal monopolistic policy interventions is often instructive to determine whether it is plausible that a given intervention is for domestic or monopolistic reasons. In the following, we describe optimal monopolistic capital account interventions along a number of dimensions. If the observed interventions of a policymaker are inconsistent with these observations, then they are likely not for monopolistic reasons. Recall the definition of the elasticity $\mathcal{E}^i_{Q,M} = -\omega^i Q^{-i}_M (M^i/Q)^T$, and let us discuss the various parameters:

Country Size ω^i The optimal monopolistic intervention is directly proportional to the country's weight ω^i in the world economy. Larger countries have a greater impact on the rest of the world since market clearing requires $M^{-i} = \omega^i M^i$. For example, if a small open economy with $\omega^i \approx 0$ and undifferentiated exports regulates capital in- or outflows, the reason cannot be monopolistic.

Responsiveness of Price Q^{-i}_M Monopolistic intervention requires that world market prices are sufficiently responsive to changes in consumption. If there are, for example, close substitutes to the goods traded by country i, this is unlikely to be the case.

Direction and Magnitude of Flows M^i The intervention to manipulate a given price Q_t is directly proportional to the magnitude of a country's net imports M^i_t in that time period/good/state of nature. The larger M^i_t in absolute value, the greater the revenue benefits from distorting the price Q_t. By contrast, if $M^i_t \approx 0$, the optimal monopolistic intervention is zero.

The direction and magnitude of flows has the following implications for monopolistic behavior:

- **Intertemporal trade:** In our example 2.1 with a single consumption good per time period, the elements of M^i capture net capital flows or equivalently the trade balance. In time periods in which the trade balance is close to zero $M^i_t \approx 0$, it is impossible to distort intertemporal prices. By contrast, monopolistic reasons may be involved if a country with a large deficit $M^i_t > 0$ taxes inflows $\tau^i_t > 0$ to keep world interest rates lower, or vice versa for a country with a large surplus $M^i_t < 0$. If capital accounts are closed to private agents, optimal monopolistic intervention consists of reduced/increased foreign reserve accumulation.[17]

- **Risk-sharing:** In the stochastic extension of example 2.1, $M_t^i(s_t)$ denotes different states of nature. Each country has – by definition – monopoly power over its own idiosyncratic risk. Optimal risk-sharing implies greater inflows (imports) in bad states and greater exports in good states of nature. A planner who exerts monopoly power would restrict risk-sharing so as to obtain a higher price for the country's idiosyncratic risk and to reduce the price of insurance from abroad. By contrast, if a country encourages insurance (e.g. by encouraging FDI and forbidding foreign currency debt; see Korinek, 2010), then the motive is unlikely to be monopolistic.
- **Intratemporal trade:** Exercising monopoly power in intratemporal trade consists of tariffs $\tau_{t,k}^i > 0$ on imported goods k with $M_{t,k}^i > 0$ and taxes on exports $\tau_{t,k}^i < 0$ for $M_{t,k}^i < 0$, as is well known from a long literature on trade policy (see e.g. Bagwell and Staiger, 2002).

In all these cases, observe that the optimal monopolistic intervention typically reduces the magnitude of capital or goods flows but does not change their direction.

It is straightforward that any price intervention τ^i can also be implemented by an equivalent quantity restriction $\bar{M}^i$, for example by imposing a quota rather than a tax on inflows.

5.3 Monopolistic Use of Domestic Policy Instruments

A policymaker can also use domestic policies ζ^i to monopolistically distort her country's terms of trade. This may be desirable if she faces restrictions on the set of external policy instruments, for example due to international agreements or due to technical difficulties in targeting or implementing capital controls. If the set of external policy instruments τ^i is complete, then it would be suboptimal to distort domestic policies for monopolistic reasons and only external instruments are used for this purpose:

Lemma 6 *A monopolistic planner who has a complete set of external instruments τ^i will not distort domestic policies ζ^i to exert market power.*

[17]For example, when policymakers reduce reserve accumulation because they are concerned that they are pushing down the world interest rate too much, this is classic non-competitive behavior and is equivalent to monopolistic capital controls. This corresponds to statements by some Chinese policymakers that were concerned about pushing down US Treasury yields because of their reserve accumulation.

Proof. The proof follows from the separability result in appendix A.1. In particular, observe that the implementability constraint on external transactions is slack when the planner has complete instruments and therefore $\mu_e^i = 0$. As a result, the optimality condition for domestic instruments ζ^i is unchanged. ■

To illustrate how domestic policy instruments are used for monopolistic reasons, we consider the extreme case of a monopolistic planner who cannot use external policy instruments at all so $\tau^i = 0$.[18] Furthermore, for simplicity, assume that the planner faces no domestic targeting problems so that she can choose X^i without any restrictions. This allows us to ignore the domestic optimization problem of private agents and treat the vector X^i as part of the vector of policy instruments $\zeta^i = \{X^i, \tilde{\zeta}^i\}$ for ease of notation. A monopolistic planner under these assumptions solves

$$\max_{M^i,\zeta^i,\lambda_e^i} U^i(\zeta^i) \qquad \text{s.t.} \qquad \begin{aligned} & f^i(M^i, M^i, \zeta^i) \leq 0, \\ & Q^{-i}\left(-\omega^i M^i\right) \cdot M^i \leq w_0^i, \\ & \lambda_d^i f_m^i = -\lambda_e^i Q^{-i}\left(-\omega^i M^i\right) \end{aligned}$$

The domestic constraint and external budget constraint in the first two lines are the usual ones, but the planner internalizes the effects of her external allocations on world market prices $Q^{-i}(-\omega^i M^i)$. The implementability constraints in the third line reflect that the planner lacks policy instruments to create a wedge in the external optimality condition of private agents. We assign the usual shadow prices Λ_d^i, Λ_e^i and μ_e^i to these constraints and obtain the optimality conditions

$$\begin{aligned} FOC\left(M^i\right) &: \ 0 = \Lambda_d^i f_{m+M}^i + \Lambda_e^i Q\left(1 - \omega^i \mathcal{E}_{Q,M}^{-i}\right) + \mu_e^i\left[\lambda_d^i f_{m(m+M)}^i - \omega^i \lambda_e^i Q_M^{-i}\right] \\ FOC\left(\zeta^i\right) &: \ U_\zeta^i = \Lambda_d^i f_\zeta^i + \mu_e^i\left(\lambda_d^i f_{m\zeta}^i\right) \\ FOC\left(\lambda_e^i\right) &: \ 0 = \mu_e^i \cdot Q^T \end{aligned}$$

where we denote the sum of partial derivatives as $f_{m+M} = \frac{\partial f}{\partial m} + \frac{\partial f}{\partial M}$ and so on to condense notation. The optimality condition on λ_e^i implies that the price-weighted sum of shadow prices on the external implementability constraint (IC) is zero so $\sum_k \mu_{e,k}^i Q_k = 0$. With the exception of knife-edge cases (e.g. no monopoly power because $\omega^i = 0$), some of the shadow prices on the external IC will therefore be positive and some will be negative. In particular, if we collect the first two terms in the optimality condition on M^i in the vector $-V_{m+M}^i$, we can write the condition as

$$\mu_e^i = A^{-1}\left[V_{m+M}^i - \Lambda_e^i Q\left(1 - \omega^i \mathcal{E}_{Q,M}^{-i}\right)\right]$$

where $A = \lambda_d^i f_{m(m+M)}^i - \omega^i \lambda_e^i Q_M^{-i}$ is a negative semidefinite matrix. To interpret this expression, consider an A that is close to diagonal and assume that there are no

[18] We could also place a more general set of restrictions on the set of policy instruments, e.g. $\Xi\left(\tau^i\right) \leq 0$. Our main insight that a monopolistic planner would use domestic policy instruments to distort external allocations would continue to hold.

domestic externalities so $V^i_m = V^i_{m+M}$.[19] In the absence of monopolistic behavior, the square brackets in this expression would be zero by the private optimality condition of consumers $V^i_m = \lambda^i_e Q$. By contrast, for a monopolistic planner, the vector of shadow prices μ^i_e captures the monopolistic cost (benefit) of increasing imports of each good and is therefore negative for net imports and positive for net exports.

In setting the optimal domestic allocation and policy measures ζ^i according to $FOC\left(\zeta^i\right)$, the planner internalizes that the marginal domestic cost of consumption or policy measures $\Lambda^i_d f^i_\zeta$ needs to be complemented by the monopolistic benefits or costs.

Example: [**fiscal policy/fiscal stimulus – to be completed**]

6 Imperfect External Policy Instruments

In practice policymakers do not have the set of perfect external policy instruments that we have depicted in our earlier analysis (see e.g. Carvalho and Marcio, 2006, in the context of capital controls). This section analyzes under what circumstances imperfections in the set of policy instruments create a case for global policy coordination. We first discuss circumstances under which the set of policy instruments is effectively complete even if there are limitations on actual instruments. Then we analyze two types of such imperfections: implementation costs and imperfect targeting. We formalize both and analyze when and how a global planner can achieve a Pareto improvement by coordinating the imperfect policy instruments of different countries.

6.1 Completeness of Set of External Instruments

Definitions A policymaker in country i has a *complete set of external policy instruments* τ^i if the policymaker has sufficient instruments to implement any feasible external allocation as a decentralized allocation, i.e. $\forall M^i$ s.t. $Q \cdot M^i = w^i_0$, $\exists \tau^i$ s.t. $M^i = M^i\left(Q, \tau^i, w^i_0\right)$. In the baseline setup of section 2, the set of policy instruments is complete by construction.

Conversely, a policymaker in country i has an *incomplete set of external policy instruments* τ^i if there are feasible external allocations that the planner cannot implement as a decentralized allocation, i.e. $\exists M^i$ with $Q \cdot M^i = w^i_0$ s.t. $\nexists \tau^i$ s.t. $M^i = M^i\left(Q, \tau^i, w^i_0\right)$. Clearly, the two definitions are exhaustive and mutually exclusive, i.e. every set of external policy instruments is either complete or incomplete.

[19] This assumption holds exactly if m^i enters in Cobb-Douglas fashion. In the general case, the diagonal elements of the matrix are likely to be an order of magnitude larger than the off-diagonal elements as long as goods aren't strong complements or substitutes.

A policymaker in country i has an *effectively complete set of external policy instruments* τ^i if the policymaker has sufficient instruments to implement the optimal allocation that she would choose if she had a complete set of external instruments, i.e. $\exists \tau^i$ s.t. $M^i\left(Q, \tau^i, w_0^i\right) = \arg\max_{M^i} V\left(M^i, M^i\right)$ s.t. $Q \cdot M^i = w_0^i$. If a policymaker's set of external instruments is complete, it is also effectively complete, but not vice versa – it is possible that the planner has sufficient instruments to implement the optimal allocation but not all other feasible allocations.

Effective Completeness and Efficiency Our efficiency result in proposition 1 requires that the policymakers in each country have at least an effectively complete set of external policy instruments. In that case, each policymaker can choose her desired allocations, and the logic of the first welfare theorem applies. Observe that only effective completeness in external instruments is required. No matter how incomplete the set of domestic policy instruments is, our efficiency proposition holds since a global planner cannot improve on the allocation given the restrictions on domestic instruments.

The case $V_M^i = 0$ of no externalities in international transactions represents a benchmark case in which the set of instruments of the policymaker in country i is always effectively complete. In that case, incompleteness in actual policy instruments is irrelevant since the laissez faire external allocation implements the efficient allocation.

Effective Completeness at the Global Level The set of external policy instruments $\left(\tau^i\right)_{i=1}^N$ is *effectively complete at the global level* if a global planner can implement a Pareto efficient equilibrium for a given set of welfare weights. A given set $\left(\tau^i\right)_{i=1}^N$ may be effectively complete at the global level even if the set of policy instruments τ^i in some country i is not effectively complete. In that case a global planner can implement a Pareto efficient equilibrium that is unattainable without global cooperation. Effective completeness at the global level is thus a weaker condition than effective completeness in each country i. The reason for the discrepancy between the two concepts is captured by lemma 3: there is a continuum of ways of implementing a given global allocation, but only one of these implementations corresponds to a global competitive equilibrium in which national policymakers act unilaterally. A global planner may be able to employ one of the other implementations if the implementation through a competitive equilibrium is unavailable.

Example 6.1 (Effectively Complete Instruments at the Global Level) Consider a world economy with $N = 2$ countries that are described by the reduced-form utility functions $V^i\left(m^i, M^i\right)$. Assume that country 1 suffers from externalities to capital inflows so $V_M^1 \neq 0$ but does not have any policy instruments to correct for them. Furthermore, assume that country 2 does not suffer from externalities $V_M^2 \equiv 0$ but has a complete set of external instruments τ^2.

If country 1 had the instruments to do so, it would impose an optimal tax on capital inflows $\tau_0^{1*} = -\left(V_M^1/V_m^1\right)^T$. However, since the country has no policy instruments, the global competitive equilibrium coincides with the laissez-faire equilibrium – country 2 has no incentive to intervene in its external transactions.

By contrast, under cooperation, country 2 would set its policy instrument $1-\tau_0^2 = \frac{1}{1-\tau_0^{1*}}$, i.e. it would tax capital outflows to correct for the negative externalities of inflows in country 1 and implement a Pareto efficient allocation.

6.2 Imperfections in Set of External Instruments

To formally capture imperfections in the set of instruments of a policymaker in country i, we assume that there is a cost to imposing the set of policy instruments τ^i given by a function $\Gamma^i(\tau^i)$ that is non-negative, satisfies $\Gamma^i(0) = 0$, is convex and continuously differentiable, and that negatively enters the planner's objective $U^i(X^i) - \Gamma^i(\tau^i)$.[20]

This formulation is able to capture a large number of imperfections in the set of instruments:[21] First, if we index the elements of vector τ^i by the letter t, a cost function of the simple quadratic form $\Gamma^i(\tau^i) = \sum_t \gamma_t^i \left(\tau_t^i\right)^2/2$ may capture implementation costs that arise from policy intervention and that grow in the square of the intervention. The chosen specification allows for this cost to vary across different elements of the vector τ^i by adjusting γ_t^i, for example $\gamma_t^i = \beta^t \bar{\gamma}^i$. Secondly, if we assume the limit case $\gamma_t^i \to \infty$ for some t, the cost function captures that instrument τ_t^i is not available. In the extreme case of $\gamma_t^i \to \infty\ \forall t$, country i has no external policy instruments. Thirdly, if we index the vector τ^i both by the letters t and k, for example to capture that there are different goods $k = 1...K$ in each time period t as in example 2.3, a cost function of the form $\Gamma^i(\tau^i) = \sum_t \sum_{k=2}^K \gamma\left(\tau_{t,k}^i - \tau_{t,1}^i\right)^2/2$ with $\gamma \to \infty$ captures that the planner is unable to differentiate her policy instruments across different goods and has to set $\tau_{t,k}^i = \tau_{t,1}^i \forall k$. Fourth, a similar specification $\Gamma^i(\tau^i) = \sum_t \sum_{s\in\Omega} \gamma\left(\tau_{t,s}^i - \tau_{t,s_0}^i\right)^2/2$ captures restrictions on the ability of the planner to target flows in different state of nature $s \in \Omega$. For example, the planner may be unable to differentiate between capital flows with different risk profile. Fifth, for $\Gamma^i(\tau^i) \equiv 0$, the setup collapses to our benchmark model of section 2.

6.3 Model of Imperfect Instruments

In the following, we focus on a simplified model version without domestic policy instruments and constraints ζ^i in which we assume $X^i = M^i$ so there is no role for independent domestic allocations (as for instance in our earlier example 4.1).

[20] The setup is isomorphic to one in which the cost is a resource cost that is subtracted from the external budget constraint $Q \cdot M^i \leq w_0^i - \Gamma^i\left(\tau^i\right)$.

[21] Similar results can be derived if the cost of policy intervention depends on quantities transacted, e.g. $\Gamma^i\left(\tau^i, M^i\right)$, which may for example capture the costs associated with attempts at circumvention.

The problem of a country is fully described by the reduced-form utility function $V^i(m^i, M^i)$.

A competitive national planner maximizes $V^i(M^i, M^i)$ subject to the collection of external implementability constraints $(1-\tau^i) V^i_m = \lambda^i_e Q$ and the external budget constraint (**??**), to which we assign shadow prices μ^i_e and Λ^i_e respectively. The planner's optimality condition $FOC(M^i)$ can be written to express the shadow prices on the implementability constraint μ^i_e, which captures the extent of mis-targeting,

$$\mu^i_e = \frac{{V^i_{m+M}}^T - \Lambda^i_e Q}{1-\tau^i} \cdot \left[V^i_{m(m+M)}\right]^{-1} \tag{23}$$

The mis-targeting indicator $\mu^i_{e,t}$ is negative for those elements of the import vector M^i that are less than optimal, i.e. for which the marginal social value is greater than the market price, $V^i_{m+M,t} > \Lambda^i_e Q_t$, and positive in the converse case, since the matrix $V^i_{m(m+M)}$ is negative semi-definite. For those elements of M^i for which the planner has perfect instruments, she can set $V^i_{m+M,t} = \Lambda^i_e Q_t$ and the mis-targeting is $\mu^i_{e,t} = 0$. If the planner has no external policy instruments (i.e. in the limit case that using the instruments is infinitely expensive), then the mistargeting is reflected in μ^i_e but there is nothing that the planner can do about it.

If policy instruments τ^i are available but costly, then the planner sets the instruments such that the marginal cost of the policy instruments τ^i equal the benefit from reducing the mis-targeting, as captured by the optimality condition $FOC(\tau^i)$,

$$\Gamma^{i\prime}\left(\tau^i\right) = \mu^i_e V^{i\,T}_m$$

If there are excessive flows of a good so $\mu^i_{e,t} > 0$, the planner imposes a positive tax $\tau^i_t > 0$ that leads to a positive marginal distortion $\Gamma^{i\prime}(\tau^i_t) > 0$; conversely, if flows of a good are insufficient $\mu^i_{e,t} < 0$, the planner imposes a subsidy.

The optimality condition $FOC(\lambda^i_e)$ requires that the price-weighted average mis-targeting is zero, $\mu^i_e \cdot Q^T = 0$. Compared to the laissez-faire equilibrium, the marginal valuation of wealth Λ^i_e in equation (23) adjusts to ensure that this condition is satisfied. If externalities V^i_M are on average positive, then the planner's marginal valuation Λ^i_e of will be above λ^i_e and vice versa. The optimality condition implies the following result for how the planner chooses to employ her policy instruments:

Proposition 5 (Implementation with Imperfect Instruments) *Under the constrained optimal allocation of a competitive planner, the average marginal cost of the policy instruments τ^i is zero,*

$$\Gamma^{i\prime}\left(\tau^i\right) \cdot \left(1-\tau^i\right)^T = 0 \tag{24}$$

Proof. The result is obtained by combining the optimality conditions on τ^i and λ^i_e with the external implementability constraint. ■

Intuitively, given the constraints on her instruments, the planner chooses her allocations such that flows are too low in some states and too high in others compared to the complete instruments case. The intuition goes back to lemma 3 on the indeterminacy of implementation: under complete instruments, the efficient allocation can be implemented using a continuum of policy instruments that satisfy $\left(1-\tilde{\tau}^i\right) = k\left(1-\tau^i\right)$ for some $k > 0$. Under imperfect instruments, the planner picks the implementation from within this continuum that minimizes total implementation costs. Whenever the planner finds it optimal to tax some flows, she will subsidize others, such that the weighted average distortion is zero.

The optimal tax formula under imperfect instruments satisfies[22]

$$1-\tau^i = \frac{1+\left(\frac{V_M^i}{V_m^i}\right)^T}{\frac{\Lambda_e^i}{\lambda_e^i} + \frac{\Gamma^{i\prime}}{\left(V_m^i\right)^2} V_{m(m+M)}^i}$$

If the set of instruments is effectively complete, observe that the denominator is one and the expression reduces to equation (13). Under incomplete instruments, the term $\Lambda_e^i/\lambda_e^i \gtreqless 1$ in the denominator adjusts the average level of controls so that proposition 5 is satisfied. The term $\Gamma^{i\prime}\left(\tau^i\right)$ reduces/increases the optimal level of policy intervention to account for the costs of intervention.

Example 6.2 (Costly Instruments) Consider a two-period version of an economy as described in example 4.1 in which inflows in period 0 increase output in period 1 due to an externality. Assume there is no discounting and a world price vector $Q = (1, 1)$. The reduced-form utility function net of implementation costs is

$$V^i\left(m^i, M^i\right) = u\left(y^i + m_0^i\right) + u\left(y^i - \eta^i M_0^i + m_1^i\right) - \Gamma^i\left(\tau^i\right)$$

$$\text{where} \qquad \Gamma^i\left(\tau^i\right) = \frac{\gamma^i \tau^i \cdot \tau^{i\ T}}{2}$$

Let us start from an equilibrium in which $\eta^i = 0$ and assume a small increase $d\eta^i > 0$ in the externality. Given the costly instruments, the planner will set $\tau_0^i = d\eta^i/2 = -d\tau_1^i$ such that condition (24) is satisfied. The planner taxes the externality-generating inflows (and subsidizes outflows) in period 0 but subsidizes inflows (and taxes outflows) in period 1. Since the budget constraint $\frac{Q}{1-\tau^i} \cdot m^i = w_0^i + T^i$ has to hold, the planner internalizes that higher m_1^i implies lower m_0^i and she can correct the externality while saving on implementation costs by spreading her intervention across both goods.

6.4 Global Coordination with Imperfect Instruments

We next determine under what conditions the equilibrium in which national planners impose capital controls according to equation (24) is constrained Pareto efficient.

[22] We obtain the expression by subtracting the subtracting the implementability constraint from the $FOC\left(M^i\right)$ and rearranging terms.

In other words, if national planners follow the described rule, can a global planner achieve a Pareto improvement on the resulting equilibrium?

We analyze a global planner who faces the same set of imperfect instruments and maximizes the weighted sum of welfare

$$\max_{\left(M^i,\tau^i,\lambda_e^i\right)_{i=1}^N,Q} \sum_i \phi^i\omega^i V^i\left(M^i,M^i\right)-\Gamma^i\left(\tau^i\right)$$

$$\text{s.t.} \quad \sum_i \omega^i M^i=0, \quad \left(1-\tau^i\right)V_m^i=\lambda_e^i Q^T \quad \forall i$$

for a given set of welfare weights $\left(\phi^i\right)_{i=1}^N$. As we vary the welfare weights, we describe the entire constrained Pareto frontier. We assign the vectors of shadow prices ν and μ_e^i to the resource and implementability constraints and observe that the market price Q is now a choice variable of the global planner. The implementability constraints thus capture that the post-tax private marginal products $(1-\tau^i)\,V_m^i$ of different countries must be proportional to each other.

We describe the extent of mis-targeting using the shadow prices μ_e^i by re-arranging the global planner's optimality conditions $FOC\left(M^i\right)$ to obtain

$$\mu_e^i=\frac{{V_{m+M}^i}^T-\nu/\phi^i}{1-\tau^i}\cdot\left[V_{m(m+M)}^i\right]^{-1} \quad \forall i$$

As in our analysis of national planners, a positive element $\mu_{e,t}^i$ means that the planner would like more inflows of M_t^i but cannot implement this due to the imperfect instruments. Also, the optimality condition $FOC\left(\tau^i\right)$ implies that the planner sets the instruments τ^i such that the marginal cost is proportional to the extent of mis-targeting $\Gamma^{i\prime}\left(\tau^i\right)=\mu_e^i {V_m^i}^T$.

Proposition 6 (Global Coordination with Imperfect Instruments) *In a constrained efficient equilibrium, the average marginal cost of the policy instruments τ^i in a given country is zero,*

$$\Gamma^{i\prime}\left(\tau^i\right)\cdot\left(1-\tau^i\right)^T=0 \qquad \forall i$$

Furthermore, the weighted average mis-targeting across countries is zero for each good,

$$\sum_{i=1}^N \omega^i\phi^i\Gamma^{i\prime}\left(\tau^i\right)\left(1-\tau^i\right)=0 \tag{25}$$

Proof. The first (second) result is obtained by combining the optimality conditions on τ^i and λ_e^i (τ^i and Q) with the external implementability constraint. ■

As before, the weighted average marginal distortion across different goods in the same country i is zero. However, unlike in the competitive allocation, a global planner also sets the average marginal distortion across each good equal to zero. This implies that if some countries impose taxes on inflows for certain m_t^i, others must impose taxes on outflows. In short, the planner spreads her intervention across inflow and outflow countries in proportion to their cost of intervention.

We illustrate our findings in the following examples:

Example 6.3 (Wasteful Competitive Intervention) Assume a world economy that consists of N identical countries with reduced-form utility functions $V^i\left(m^i, M^i\right)$ that experience externalities $V_M^i \neq 0$ and that suffer from implementation costs $\Gamma^i\left(\tau^i\right) = \gamma\tau^i \cdot \tau^{iT}/2$. Following proposition 5, the national planner in each country i imposes identical policy instruments $\tau^i \gtreqless 0$ and incurs the identical cost $\Gamma^i\left(\tau^i\right) > 0$.

A global planner who puts equal weight on the countries would recognize that the competitive interventions in all countries are wasteful – since the countries are identical, there is not trade $M^i = 0\forall i$ and all countries could save the cost $\Gamma^i\left(\tau^i\right)$ without changing global allocations by coordinating to reduce their policy instruments to zero. Technically, the global competitive equilibrium violates condition (25) since some $\tau_t^i > 0\forall i$ and some $\tau_t^i < 0\forall i$. The only way the planner can satisfy the optimality condition is to move all controls to zero. Observe that the set of instruments is effectively complete at the global level even though all N countries have incomplete/imperfect instruments.

Example 6.4 (Sharing the Regulatory Burden) Consider a world economy consisting of $N = 2$ economies as described in example 6.2 with utility functions given by (**??**) and cost functions $\Gamma^i\left(\tau^i\right) = \frac{\gamma^i\tau^i \cdot \tau^{i\ T}}{2}$. Assume an equilibrium with $\eta^1 = \eta^2 = 0$ and consider the effects of a small increase $d\eta^1 > 0$ in country 1's externalities. In the global competitive equilibrium, the planner in country 1 would behave as described in example 6.2, but the resulting allocation would clearly violate condition (25) since $\tau_0^1 > 0 > \tau_1^1$.

A global planner with equal welfare weights would share the regulatory burden among both countries to minimize the total cost of intervention. Specifically, the planner would set the policy instruments in accordance with the relative cost of intervention,

$$d\tau_0^1 = \frac{\gamma^2 d\eta}{2\left(\gamma^1 + \gamma^2\right)} = -d\tau_1^1 \qquad \text{and} \qquad d\tau_0^2 = -\frac{\gamma^1 d\eta}{2\left(\gamma^1 + \gamma^2\right)} = -d\tau_1^2$$

If the cost of intervention is equal among the two countries, then the fractions are 1/4 and the planner corrects one quarter of the externality in each time period in each country to implement the constrained efficient equilibrium. For given $\gamma^1 > 0$, in the limit case of $\gamma^2 \to 0$, the planner would only intervene in country 2 and fully correct the externality there. In the limit case $\gamma^2 \to \infty$, the planner would only intervene in country 1 and leave $\tau^2 = 0$.

In summary, our examples illustrate that the rational for global cooperation is to avoid wasteful competitive regulation and to shift the regulatory burden towards those who are best able to implement it.

Scope for Pareto Improvement One caveat to the cooperative agreements described in this section is that our planning setup implicitly assumes that lump-sum transfers are available. Sharing the regulatory burden generally involves a shift in world market prices that may create winners and losers. This will be the case especially when a "helping" country taxes outflows or subsidizes inflows.

Although Pareto-improvements are not always possible, there are two constellations under which cooperation does constitute Pareto-improvements: (i) if there is no trade as in our example 6.3 on wasteful competition and (ii) if the savings from the marginal cost of an instrument $\Gamma^{i\prime}(\tau_t^i)$ in the country that suffers the terms-of-trade loss is greater than the loss. Both examples are unlikely to be commonplace.

6.5 Domestic Policy under Imperfect External Instruments

We now return to the full setup of our baseline model with domestic instruments and policy measures $\left(X^i, \zeta^i\right)$ in order to study the effects of incomplete external policy instruments on domestic allocations.

Lemma 7 (Non-Separability) *If a competitive planner has a set of instruments that is not effectively complete, she distorts her domestic policy choices ζ^i as a second-best device to target external transactions.*

Proof. Since $\mu_e^i \neq 0$, the optimality condition $FOC\left(\zeta^i\right)$ is affected by the imperfect targeting of external transaction (see appendix A.1). ∎

Intuitively, the planner uses not only domestic considerations in setting her policy instruments ζ^i but also considers how her choices will improve external allocations, which she can only imperfecty target with the external instruments τ^i. For example, if ζ_t^i is complementary to m_t^i and m_t^i is excessive, then the planner will reduce ζ_t^i to bring down m_t^i.

[to be completed]

7 Imperfect International Markets

This section analyzes how global cooperation can improve outcomes if there are imperfections in international markets. We first show that if each country has a full set of external policy instruments τ^i, such cooperation will be limited to setting these external policy instruments and there is no need to coordinate the use of domestic policy measures ζ^i. Next we provide several examples of imperfections in international markets and how cooperation can improve outcomes.

Cooperation with Complete Instruments [to be completed]

8 Conclusions

This paper has studied the effects of national economic policies in a general equilibrium model of the world economy and has delineated under what conditions economic policy coordination is desirable from a global welfare perspective. In our positive analysis, we found that the policy interventions of national economic policymakers can have significant spillover effects on other countries.

In our normative analysis, however, we emphasized that these spillover should generally be viewed as pecuniary externalities that are efficient as long as (i) national policymakers are price-takers in the international market, (ii) they possess a complete set of instruments to control transactions with the rest of the world so they can actually implement their preferred choices and (iii) international markets are complete. Under these conditions, the first welfare theorem applies at the level of national economic policymakers.

We then illustrated our result in the context of a number of different motives for intervening in capital accounts. Generally, we found that if a national economic policymaker intervenes to combat national externalities, then the interventions are Pareto efficient from a global welfare perspective and there is no need for global coordination of such policies.

Our analysis provides conceptual foundations for determining under what circumstances international policy cooperation is warranted, but to determine when these circumstances are satisfied in practice is still a difficult problem. We discussed, for example, how to detect monopolistic behavior and how to identify symptoms of targeting problems. However, we also emphasized that there are frequently confounding factors that make it more difficult to identify such circumstances.

Another important research area is how to implement Pareto-improving cooperation in practice. Willett (1999) discusses a range of political economy problems that make international policy cooperation difficult. Bagwell and Staiger (2002), among others, provide an analysis of how to achieve agreements to abstain from monopolistic beggar-thy-neighbor policies if countries are sufficiently symmetric. A careful treatment of this question is beyond the scope of this article.

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A Mathematical Appendix

A.1 Combined Optimization Problem

Proof of Lemma 2 (Separability) We describe the Lagrangian of the combined optimization problem of an individual agent (while suppressing the vector of exogenous parameters Z^i) as

$$w^i\left(m^i, x^i; M^i, X^i, \zeta^i, T^i\right) = \max_{m^i, x^i} U^i\left(x^i\right) \qquad -\lambda_d^i \cdot f^i\left(m^i, x^i, M^i, X^i, \zeta^i\right)$$
$$-\lambda_e^i\left[\frac{Q}{1-\tau^i} \cdot m^i - w_0^i - T^i\right]$$

The optimality conditions are given by the vector equations

$$FOC\left(x^i\right) \quad : \quad U_x^i = f_x^{i\,T} \lambda_d^{i\,T}$$
$$FOC\left(m^i\right) \quad : \quad \lambda_d^i f_m^i + \lambda_e^i \frac{Q}{1-\tau^i} = 0$$

These two conditions represent domestic and external implementability constraints on the national planner's problem, which is given by the Lagrangian

$$W^i\left(M^i, X^i, \zeta^i, \tau^i\right) = \max_{M^i, X^i, \zeta^i, \tau^i, \lambda_d^i, \lambda_e^i} U^i\left(X^i\right) \qquad -\Lambda_d^i \cdot f^i\left(M^i, X^i, M^i, X^i, \zeta^i\right) \tag{A.1}$$
$$-\Lambda_e^i\left[Q \cdot M^i - w_0^i\right] \tag{A.2}$$
$$-\mu_d^i \cdot \left[U_x^i - f_x^{i\,T} \lambda_d^{i\,T}\right] \tag{A.3}$$
$$-\mu_e^i \cdot \left[\lambda_d^i f_m^i + \lambda_e^i \frac{Q}{1-\tau^i}\right]^T \tag{A.4}$$

and delivers the associated optimality conditions (with all multiplications and divisions in the $FOC\left(\tau^i\right)$ calculated element-by-element)

$$FOC\left(X^i\right) \quad : \quad U_x^i = \left(f_x^i + f_X^i\right)^T \Lambda_d^{i\,T} + U_{xx}^{i\ T} \mu_d^{i\,T} \tag{A.5}$$
$$- \sum_k \left[\mu_{d,k}^i \left(f_{xx_k}^i + f_{xX_k}^i\right)^T \lambda_d^{i\,T} - \mu_{e,k}^i \left(f_{mx_k}^i + f_{mX_k}^i\right)^T \lambda_d^{i\,T}\right]$$

$$FOC\left(M^i\right) \quad : \quad 0 = \left(f_m^i + f_M^i\right)^T \Lambda_d^{i\,T} + \Lambda_e^i Q^T \tag{A.6}$$
$$- \sum_k \left[\mu_{d,k}^i \left(f_{xm_k}^i + f_{xM_k}^i\right)^T \lambda_d^{i\,T} - \mu_{e,k}^i \left(f_{mm_k}^i + f_{mM_k}^i\right)^T \lambda_d^{i\,T}\right]$$

$$FOC\left(\zeta^i\right) \quad : \quad 0 = f_\zeta^{iT} \Lambda_d^{i\,T} - \sum_k \left[\mu_{d,k}^i f_{x\zeta_k}^{i\ T} \lambda_d^{\,T} - \mu_{e,k}^i f_{m\zeta_k}^{i\ T} \lambda_d^{i\,T}\right] \tag{A.7}$$

$$FOC\left(\tau^i\right) \quad : \quad 0 = \mu_e^i \left[\frac{\lambda_e^i Q}{\left(1-\tau^i\right)^2}\right] \tag{A.8}$$

$$FOC\left(\lambda_d^i\right) \quad : \quad 0 = -\mu_d^i f_x^{i\,T} + \mu_e^i f_m^{i\ T} \tag{A.9}$$

$$FOC\left(\lambda_e^i\right) \quad : \quad 0 = \mu_e^i \cdot \left(\frac{Q}{1-\tau^i}\right)^T \tag{A.10}$$

Given the complete set of external instruments τ^i, the system of optimality conditions $FOC\left(M^i, \tau^i, \lambda_e^i\right)$ implies that the vector of shadow prices on the external implementability constraint satisfies $\mu_e^i = 0$ – the planner sets the vector τ^i to whichever levels she wants without facing trade-offs. By implication, the last term in the other five optimality conditions drops out, allowing us to separate the problem into two blocks.

The optimality conditions (A.5), (A.7) and (A.9) with $\mu_e^i = 0$ replicate the optimality conditions of the optimal domestic planning problem (7) in section 3.1. Together with the domestic constraint (A.1) and the domestic implementability condition (A.3), these five conditions are identical to the five conditions that pin down the optimal domestic allocation for given M^i in section 3.1 and yield identical solutions for the five domestic variables $\left(X^i, \zeta^i, \lambda_d^i, \Lambda_d^i, \mu_d^i\right)$.

Given the envelope theorem, the optimality condition (A.6) can equivalently be written as $\partial W^i/\partial M^i = dV^i/dM^i = 0$, where the latter condition coincides with the optimality condition (12) defining the optimal external allocation in section 3.2. The optimality conditions (A.8) and (A.10) for $\mu_e^i = 0$ capture that the planner can set the product $\lambda_e^i\left(1-\tau^i\right)$ such as to precisely meet the constraints (A.4) where the planner has one scalar degree of freedom, as we also emphasized in section 3.2. The three optimality conditions together with the two constraints yield an identical set of solutions for the five external variables $\left(M^i, \tau^i, \lambda_e^i, \Lambda_e^i, \mu_e^i\right)$ as we described in section 3.2. This shows that the two-step procedure that separates domestic and external optimization as described in section 2 yields identical solutions as the combined optimization problem described here.