Monetary Policy in an Unbalanced Global Economy

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Abstract

We study optimal monetary policy during times of exceptionally high global demand for tradable goods, relative to non-tradable ones. The optimal monetary response entails a rise in inflation, which helps rebalance production towards the tradable sector. While the inflation costs are fully bore domestically, however, the gains in terms of higher supply of tradable goods partly spill over to the rest of the world. National central banks may thus fall into a coordination trap, and implement an excessively tight monetary policy causing an unnecessarily sharp global contraction.

JEL Codes: E32, E44, E52, F41, F42.

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1 Introduction

The recovery from the Covid-19 recession has been deeply unbalanced. With the start of the pandemic, in fact, consumers reallocated expenditure from services to goods (Figure 1). While goods are typically traded internationally, most services are not, so global demand effectively concentrated on the tradable components of the consumption basket. This tradable-biased surge in demand triggered a global scarcity of manufactured goods, which manifested itself with stress on the international supply chains and rises in goods prices. Central banks reacted by engaging in a synchronized monetary tightening to cool down inflation, sparking a debate about the potential gains from international monetary cooperation (Frankel, 2022; Obstfeld, 2022).

Motivated by these facts, in this paper we study the optimal conduct of monetary policy during times of exceptionally high demand for tradable goods. We show that - under certain circumstances - national monetary authorities may fall prey of a coordination failure. In a nutshell, the reason is that the optimal monetary response entails a rise in the price of tradables, which helps rebalance production toward the tradable sector. While the inflation costs are fully bore domestically, however, the gains in terms of higher supply of tradable goods partly spill over to the rest of the world. Self-oriented national central banks do not internalize this spillover, and may thus go too far in their efforts to contain inflation, causing an unnecessarily harsh global slump.

We formalize this insight with the help of a multi-country Keynesian model with multiple sectors. Our world is composed of a continuum of small open economies. Each country employs labor to produce a tradable good, common to every country, and a non-tradable one. Due to the presence of nominal wage rigidities, monetary policy has real effects and involuntary unemployment is possible. In line with empirical evidence (Boehm and Pandalai-Nayar, 2022), sectoral supply curves are convex because production is subject to capacity constraints. Prices thus rise sharply in sectors in which production is unusually high, while they do not fall much in sectors operating at a low level of capacity utilization. We study the response of the economy to a demand reallocation shock, that is a temporary rise in consumers' demand for the tradable good, relative to the non-tradable one. In our baseline scenario the shock is global, in the sense that it hits symmetrically every country in the world.[1]

Under the optimal monetary policy, global inflation rises in response to the demand reallocation shock. To see why, recall that the reallocation shock depresses demand for non-traded goods. Without nominal rigidities, lower demand for non-tradables would simply translate into a drop in their price. Since nominal wages are rigid, however, lower demand induces firms in the non-traded sector to reduce production and fire workers. To contain the ensuing increase in unemployment, monetary policy has to facilitate a shift of employment toward the traded sector, or to boost demand for non-tradable goods. A rise in the price of the traded good achieves both objectives. First, higher prices induce firms in the traded sector to hire more workers and increase production.

[1] In this paper, we take the change in consumers' expenditure pattern as a primitive shock. In practice, several factors may have contributed to it. For sure, the pandemic itself induced households to move away from contact-intensive services in favor of physical goods that can be enjoyed at home. Especially in the case of the United States, fiscal transfers may have also played a role by boosting expenditure on durable goods.

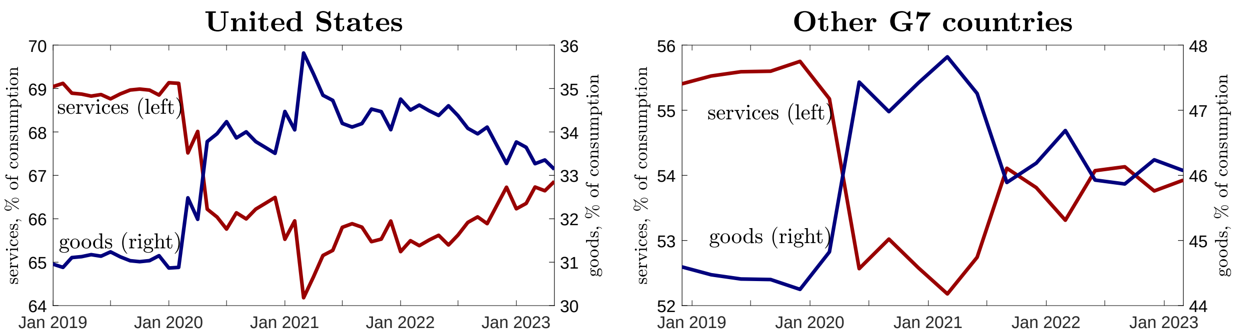

Figure 1: Goods and services share in total consumption expenditure. Notes: The figure shows the reallocation of consumption expenditure out of services and towards goods that has characterized advanced economies since the start of the Covid-19 pandemics. Other G7 countries refer to the average of Canada, France, Germany, Italy, Japan and United Kingdom. Data sources: BEA (U.S.), OECD (U.K., Japan), Eurostat (France, Germany, Italy), Statistics Canada (Canada).

Second, higher production in the traded sector increases households' income, boosting their demand for the non-traded good. Through this aggregate demand effect, higher inflation in the traded sector lifts employment in the non-traded sector too.[2]

A demand reallocation shock thus acts as an adverse cost-push shock, worsening the trade off between inflation and employment faced by central banks. The optimal monetary policy response depends on the disutility attached by society to inflation. If the inflation cost is low enough, monetary authorities let inflation rise until full employment is restored. Otherwise, both inflation and unemployment increase in response to a reallocation shock. This stagflation scenario is more likely to materialize when the shock is large and central banks attach a high weight to their price stability mandate. These results essentially extend to our setting the insights of the literature on inflation and reallocation shocks in closed economies (Olivera, 1964; Tobin, 1972; Guerrieri et al., 2021). What comes next, however, is new.

In open economies, monetary interventions trigger international spillovers mediated by capital flows. Consider a country implementing a monetary contraction to cool down inflation. The monetary contraction appreciates the exchange rate, leading to lower domestic production of tradables, and attracts capital inflows. The resulting trade deficit sustains domestic consumption - therefore mitigating the impact of the monetary tightening on employment in the non-traded sector - but exacerbates the global scarcity of tradable goods. The rest of the world, in fact, suffers capital outflows and trade surpluses. Foreign central banks can react in two ways. They can either let their exchange rate depreciate, thus importing inflation. Or they can tighten monetary policy themselves, leading to a drop in demand and employment in the non traded sector. Through this channel, a monetary contraction exports inflation and unemployment to the rest of the world.[3]

[2]Our model also embeds a third effect. A rise in the price of tradables generates an expenditure switching effect from the tradable to the non-tradable good, thus sustaining employment in the non-traded sector.

[3]The model thus captures the notion, popular in the 1980s, that trade deficits and exchange rate appreciations shift part of the costs of a disinflation from the domestic economy to the rest of the world. For instance, Sachs (1985) argues that the combination of trade deficits and strong dollar eased the pain of the 1980s disinflation in the United States, but exported inflation abroad. This logic also suggests that, once again, during the recovery from Covid-19

Are there gains from international monetary cooperation? The answer is a qualified yes. If maintaining full employment is not too costly in terms of inflation, in fact, international cooperation is not needed. Instead, if monetary authorities are willing to sacrifice full employment to contain inflation, the cooperative equilibrium breaks down as national central banks engage in competitive appreciations. The reason is simple. The disinflation gains associated with monetary contractions are fully enjoyed domestically, while the losses in terms of lower demand are partly suffered by the rest of the world. Not internalizing this spillover, national central banks hike their policy rate in an attempt to reduce domestic inflation by appreciating the exchange rate and importing foreign capital. However, in a symmetric equilibrium the impact of monetary tightenings on exchange rates and capital flows washes out. All that is left is an excessively tight monetary stance, leading to an unnecessarily sharp global contraction.[4]

In the last part of the paper we discuss some other implications of our model. First, we show that, under the optimal monetary policy, nominal interest rates rise in response to a reallocation shock. Second, we show that the rise in inflation caused by a demand reallocation shock is accompanied by an increase in the profit share and a drop in real wages. When the shock dissipates and demand normalizes real wages recover. Moreover, during the demand normalization phase nominal wage growth and inflation in the non-traded sector overshoot their long-run values, while the traded sector goes through a period of deflation. All these features are consistent with the recent experience of the United States and the euro area (Lane, 2023). Finally, we briefly study supply disruptions hitting the tradable sector, and argue that they trigger dynamics very similar to tradable-biased surges in demand, because both shocks induce global scarcity of tradable goods.

This paper is related to two strands of the literature. First, it is connected to the literature studying monetary policy during times of sectoral demand reallocation. Olivera (1964) and Tobin (1972) are classic contributions to this literature, while Aoki (2001), Benigno and Ricci (2011), Guerrieri et al. (2021) and Ferrante et al. (2023) provide analyses based on modern Keynesian frameworks. All these works consider closed economies, and so abstract from interactions across different countries, which are the focus of our work.[5] In an interesting contribution, Di Giovanni et al. (2022) examine the impact of the Covid-19 pandemic on the US and the euro area. Their framework encompasses several shocks, including demand reallocation shocks, and allows for international trade linkages, but not capital flows and trade imbalances. Different from their work, we study the optimal monetary policy and the gains from international cooperation in a global economy with capital mobility. We thus see Di Giovanni et al. (2022) as complementary to our paper. Fornaro (2018) investigates the implications for monetary policy of a global deleveraging shock, using a multi-country model with multiple sectors. Here, instead, we consider a demand re-

trade deficits and a strong dollar helped to contain US inflation, but increased inflationary pressures in the rest of the world.

[4]Note the contrast with the notion of competitive depreciations. Competitive depreciations, however, are typically an issue when global demand is weak and inflation is low, such as the Great Depression or the Great Recession. We study a different scenario, characterized by global scarcity of tradable goods and high inflation. This explains why in our model competitive appreciations pose a challenge to international cooperation.

[5]In a recent paper, Bianchi and Coulibaly (2023) also study demand reallocation shocks in open economies. Their work is subsequent to and builds on our own paper.

allocation shock and we study the gains from international monetary cooperation, two dimensions which are absent in Fornaro (2018).

Second, our paper is related to the vast literature on international monetary policy cooperation. Oudiz and Sachs (1984) is an early example. Obstfeld and Rogoff (2002), Benigno and Benigno (2003) and Corsetti and Pesenti (2005) study international monetary policy cooperation using new-Keynesian open-economy models.[6] In these frameworks, the gains from cooperation arise because individual countries have an incentive to manipulate their terms of trade at the expenses of the rest of the world. In our model, terms of trade are constant and independent of government policy, and hence terms of trade externalities are absent. Canzoneri et al. (2005) and Tille (2002) consider the gains from cooperation in multi-sector economies subject to sectoral shocks. Their focus is on asymmetric shocks, while we study a scenario in which the whole world is hit by a reallocation shock. Moreover, the source of gains from cooperation emphasized by our paper is, to the best of our knowledge, novel compared to the existing literature. Our model is also connected to some recent works studying international spillovers in times of secular stagnation (Caballero et al., 2021; Eggertsson et al., 2016; Fornaro and Romei, 2019). These papers consider a global economy in which demand is scarce and inflation is low. Instead, we analyse a scenario in which global demand is strong and inflation is high.

The rest of the paper is composed of six sections. Section 2 introduces our model. Section 3 studies the macroeconomic adjustment to a demand reallocation shock under financial autarky. Section 4 considers the case of free capital mobility. Section 5 examines international spillovers and potential gains from monetary cooperation. Section 6 discusses several extensions to our basic framework. Section 7 concludes.

2 Model

We consider a world composed of a continuum of measure one of small open economies indexed by $i \in [0, 1]$. Each economy can be thought of as a country. Time is discrete and indexed by $t \in \{0, ...\}$. Since the presence of risk is not crucial for our results, agents have perfect foresight.

Throughout, we will interpret period 0 as the short run, and periods $t \geq 1$ as the long run. In particular, we will assume that in period 0 the economy is hit by a reallocation shock, driving up the demand for tradable goods relative to non-tradable ones. Thereafter, the economy goes back to steady state. We are interested in understanding the role of international capital flows in shaping the adjustment to this reallocation shock, so we will compare two financial regimes: financial autarky and free capital mobility.

[6] See also Bodenstein et al. (2020), Egorov and Mukhin (2020), Jeanne (2021) and Auclert et al. (2023) for some recent contributions to this literature.

2.1 Households

Each country is populated by a continuum of measure one of identical infinitely-lived households. The lifetime utility of the representative household in a generic country i is

$$\sum_{t=0}^{\infty} \beta^t \left(\log (C_{i,t}) - \chi \left(\frac{P_{i,t}}{P_{i,t-1}} \right) \right), \tag{1}$$

where $0 < \beta < 1$ is the subjective discount factor. Households derive utility from aggregate consumption $C_{i,t}$, defined as

$$C_{i,t} = \left(\frac{C_{i,t}^T}{\omega_{i,t}} \right)^{\omega_{i,t}} \left(\frac{C_{i,t}^N}{1 - \omega_{i,t}} \right)^{1-\omega_{i,t}}.$$

In this expression, $C_{i,t}^T$ and $C_{i,t}^N$ denote consumption respectively of a tradable and a non-tradable good, while $0 \leq \omega_{i,t} \leq 1$ is the share of tradable goods in the consumption basket.

Moreover, households experience disutility from inflation. Let $P_{i,t}$ denote the price of a unit of consumption basket, defined as

$$P_{i,t} = \left(P_{i,t}^T\right)^{\omega_{i,t}} \left(P_{i,t}^N\right)^{1-\omega_{i,t}}, \tag{2}$$

where $P_{i,t}^T$ and $P_{i,t}^N$ stand for respectively the price of a unit of tradable and non-tradable good in terms of country i currency. The convex function $\chi(\cdot)$ captures some utility cost that households experience whenever inflation deviates from the central bank's target.[7] We assume that $\chi(1) = \chi'(1) = 0$, which amounts to normalizing the inflation target to zero. Literally, these costs could arise from some behavioral bias affecting households. More broadly, one could interpret these costs as related to the risk that the economy looses its nominal anchor if inflation deviates too much from the target. Another possible interpretation is that these costs simply capture the strength of the inflation mandate assigned by society to central banks.

Each household is endowed with $\bar{L}$ units of labor. There is no disutility from working, and so households supply inelastically their endowment of labor on the market in exchange for the nominal wage $W_{i,t}$. We introduce nominal rigidities by assuming that in the short run the nominal wage $W_{i,0}$, is fixed to its value in the initial steady state $W_{i,-1}$. To simplify notation, we assume that $W_{i,0} = W_{i,-1} = 1$ in every country i. The presence of nominal wage rigidities implies that involuntary unemployment may arise in the short run. In particular, when $L_{i,0} = \bar{L}$ the economy operates at full employment, while when $L_{i,0} < \bar{L}$ there is involuntary unemployment and the economy operates below capacity. From period 1 on, wages are fully flexible and so $L_{i,t} = \bar{L}$.

Households can trade in one-period real and nominal bonds. Real bonds are denominated in units of the tradable consumption good and pay the gross interest rate $R_{i,t}$. Under financial autarky $R_{i,t}$ may differ across countries. With free capital mobility, there is instead a single world

[7] More precisely, the function $\chi(\cdot)$ is twice-differentiable everywhere and $\chi''(\cdot) > 0$.

interest rate, and so $R_{i,t} = R_t$ for all i. Nominal bonds are denominated in units of the domestic currency and pay the gross nominal interest rate $R^n_{i,t}$. $R^n_{i,t}$ is the interest rate controlled by the central bank, and thus can be thought of as the domestic policy rate.[8]

The household budget constraint in terms of the domestic currency is

$$P^T_{i,t}C^T_{i,t} + P^N_{i,t}C^N_{i,t} + P^T_{i,t}B_{i,t+1} + B^n_{i,t+1} = W_{i,t}L_{i,t} + \Pi_{i,t} + P^T_{i,t}R_{i,t-1}B_{i,t} + R^n_{i,t-1}B^n_{i,t}. \tag{3}$$

The left-hand side of this expression represents the household's expenditure. $P^T_{i,t}C^T_{i,t} + P^N_{i,t}C^N_{i,t}$ is the total nominal expenditure in consumption. $B_{i,t+1}$ and $B^n_{i,t+1}$ denote respectively the purchase of real and nominal bonds made by the household at time t.

The right-hand side captures the household's income. $W_{i,t}L_{i,t}$ is the household's labor income. $\Pi_{i,t}$ denote the income that the household derives from the ownership of firms. We assume that domestic households own all the firms in the country. $P^T_{i,t}R_{i,t-1}B_{i,t}$ and $R^n_{i,t-1}B^n_{i,t}$ represent the gross returns on investment in bonds made at time $t-1$.

The household's optimization problem consists in choosing a sequence $\{C^T_{i,t}, C^N_{i,t}, B_{i,t+1}, B^n_{i,t+1}\}_t$ to maximize lifetime utility (1), subject to the budget constraint (3) and a no Ponzi scheme constraint, taking initial wealth $P^T_{i,0}R_{i,-1}B_{i,0} + R^n_{i,-1}B^n_{i,0}$, a sequence for income $\{W_{i,t}L_{i,t} + \Pi_{i,t}\}_t$, and prices $\{R_{i,t}, R^n_{i,t}, P^T_{i,t}, P^N_{i,t}\}_t$ as given. The household's optimality conditions can be written as

$$\frac{\omega_{i,t}}{C^T_{i,t}} = R_{i,t}\frac{\beta\omega_{i,t+1}}{C^T_{i,t+1}} \tag{4}$$

$$R_{i,t} = \frac{R^n_{i,t}P^T_{i,t}}{P^T_{i,t+1}} \tag{5}$$

$$C^N_{i,t} = \frac{1-\omega_{i,t}}{\omega_{i,t}}\frac{P^T_{i,t}}{P^N_{i,t}}C^T_{i,t}, \tag{6}$$

plus the transversality condition. Equation (4) is the Euler equations for real bonds. Equation (5) is the no arbitrage condition between real and nominal bonds. Equation (6) determines the optimal allocation of consumption expenditure between tradable and non-tradable goods. Naturally, demand for non-tradables is decreasing in their relative price $P^N_{i,t}/P^T_{i,t}$. Moreover, demand for non-tradables is increasing in $C^T_{i,t}$, due to households' desire to consume a balanced basket between tradable and non-tradable goods.

2.2 Firms and production

Empirical evidence suggests that sectoral supply curves are convex (Boehm and Pandalai-Nayar, 2022). This means that sectors facing big increases in demand react mostly through rises in prices, while prices do not fall much in sectors hit by large negative demand shocks. This behavior can be

[8]Alternatively, we could allow households to trade nominal bonds denominated in foreign currencies. Given the structure of the economy, allowing households to trade foreign nominal bonds would not affect the equilibrium allocation of the model.

rationalized with the presence of technological capacity constraints, limiting firms' ability to scale up production swiftly.

To capture these notions while preserving tractability, we introduce an asymmetry in the production function between the two sectors. We assume that in the short run firms in the tradable sector - i.e. the sector with high demand pressures - face stronger diminishing returns to employment than those producing non-traded goods. In Appendix B we microfound this approach with the presence of capacity constraints, which bite when firms seek to ramp up production quickly.

Both sectors use labor to produce, and there is perfect intersectoral labor mobility.[9] Non-traded output $Y_{i,t}^N$ is produced by a large number of competitive firms using labor $L_{i,t}^N$. The production function is $Y_{i,t}^N = L_{i,t}^N$. Profits are given by $P_{i,t}^N Y_{i,t}^N - W_{i,t}L_{i,t}$, and the zero profit condition implies that in equilibrium

$$P_{i,t}^N = W_{i,t}. \tag{7}$$

Hence, in the short run the price of the non-traded good fully inherits the nominal wage rigidity.

The tradable good is produced by a unit mass of identical competitive firms. In the short run, their production function is

$$Y_{i,0}^T = \left(\frac{L_{i,0}^T - (1-\alpha)\bar{Y}^T}{\alpha\bar{Y}^T}\right)^{\alpha} \bar{Y}^T, \tag{8}$$

where $L_{i,t}^T$ is the labor allocated to the production of traded goods, $\bar{Y}^T$ denotes tradable output in the initial steady state, and $\alpha > 0$ determines the degree of diminishing returns in the tradable sector. This production function implies that increasing quickly sectoral production above its steady state value generates productivity losses. Profit maximization implies that

$$P_{i,0}^T = W_{i,0}\left(\frac{Y_{i,0}^T}{\bar{Y}^T}\right)^{\frac{1-\alpha}{\alpha}}. \tag{9}$$

The price of the traded good is thus increasing in output.[10] This expression also implies that the price of the traded good is partly flexible in the short run. Hence, nominal prices in the non-traded

[9]However, as we will see, in our economy reallocating labor in the short run toward the tradable sector generates productivity losses. These productivity losses can capture in reduced form costs linked to intersectoral labor reallocation, for instance due to the need to retrain workers.

[10]To be more precise, as we discuss in Appendix B, the production function in the traded sector is

$$Y_{i,0}^T = \begin{cases} L_{i,0}^T & \text{if } Y_{i,0}^T < \bar{Y}^T \\ \left(\frac{L_{i,0}^T-(1-\alpha)\bar{Y}^T}{\alpha\bar{Y}^T}\right)^{\alpha}\bar{Y}^T & \text{if } Y_{i,0}^T \geq \bar{Y}^T, \end{cases}$$

so it is linear when output is below $\bar{Y}^T$, and concave thereafter. $\bar{Y}^T$ can then be interpreted as the level of output after which capacity constraints start binding. The price of the traded good is then given by

$$P_{i,0}^T = \begin{cases} W_{i,0} & \text{if } Y_{i,0}^T < \bar{Y}^T \\ W_{i,0}\left(\frac{Y_{i,0}^T}{\bar{Y}^T}\right)^{\frac{1-\alpha}{\alpha}} & \text{if } Y_{i,0}^T \geq \bar{Y}^T, \end{cases}$$

and so the sectoral Phillips curve is convex, consistent with the evidence provided by Boehm and Pandalai-Nayar (2022). Throughout the paper we streamline the analysis by focusing on scenarios in which $Y_{i,0}^T \geq \bar{Y}^T$.

sector are more rigid than in the traded one.[11]

In the long run, the production function for tradable goods is linear, and so

$$Y_{i,t}^T = L_{i,t}^T \quad \text{and} \quad P_{i,t}^T = W_{i,t} \quad \text{for} \quad t \geq 1. \tag{10}$$

This assumption captures the idea that over time firms can adjust their production process to adapt to shifts in the sectoral composition of demand.

Finally, the law of one price applies to the traded good and hence

$$P_{i,t}^T = S_{i,t} P_t^T,$$

where $P_t^T = \exp\left(\int_0^1 \log P_{j,t}^T dj\right)$ is the average world price of tradables, while $S_{i,t}$ is the effective nominal exchange rate of country i, defined so that an increase in $S_{i,t}$ corresponds to a nominal depreciation.

2.3 Market clearing and definition of competitive equilibrium

Since households inside a country are identical, we can interpret equilibrium quantities as either household or country specific. For instance, the end-of-period net foreign asset position of country i is equal to the end-of-period holdings of bonds of the representative household, $NFA_{i,t} = B_{i,t+1} + B_{i,t+1}^n / P_{i,t}^T$. Under perfect foresight, the composition of the net foreign asset position between real and nominal bonds is not uniquely pinned down in equilibrium. Throughout, we resolve this indeterminacy by focusing on equilibria in which nominal bonds are in zero net supply, so that $B_{i,t}^n = 0$ for all i and t. This implies that the net foreign asset position of a country is exactly equal to its investment in real bonds, i.e. $NFA_{i,t} = B_{i,t+1}$.

Market clearing for the tradable consumption good thus requires

$$C_{i,t}^T = Y_{i,t}^T + R_{i,t-1} B_{i,t} - B_{i,t+1}. \tag{11}$$

This expression can be rearranged to obtain the law of motion for the stock of net foreign assets owned by country i, i.e. the current account

$$NFA_{i,t} - NFA_{i,t-1} = CA_{i,t} = Y_{i,t}^T - C_{i,t}^T + B_{i,t}\left(R_{i,t-1} - 1\right).$$

As usual, the current account is given by the sum of the trade balance, $Y_{i,t}^T - C_{i,t}^T$, and net interest payments on the stock of net foreign assets owned by the country at the start of the period, $B_{i,t}(R_{i,t-1} - 1)$.

Moreover, in every period the world consumption of the tradable good has to be equal to world production, $\int_0^1 C_{i,t}^T \, \mathrm{d}i = \int_0^1 Y_{i,t}^T \, \mathrm{d}i$. This equilibrium condition implies that bonds are in zero net

[11] This feature is consistent with the empirical observation that nominal prices are stickier in the service sector, compared to agriculture and manufacturing (Nakamura and Steinsson, 2008).

supply at the world level

$$\int_0^1 B_{i,t+1}\, \mathrm{d}i = 0. \tag{12}$$

Market clearing for the non-tradable consumption good requires that in every country consumption is equal to production

$$C^N_{i,t} = Y^N_{i,t} = L^N_{i,t}. \tag{13}$$

Finally, equilibrium on the labor market requires that employment is equal to firms' labor demand, which cannot exceed households' labor supply

$$L_{i,t} = L^T_{i,t} + L^N_{i,t} \leq \bar{L}. \tag{14}$$

Since wages are flexible in the long run, the expression above holds as an equality in any period $t \geq 1$.

We are now ready to define a competitive equilibrium as a path of real allocations $\{C^T_{i,t}, C^N_{i,t}, Y^T_{i,t}, Y^N_{i,t}, L^T_{i,t}, L^N_{i,t}, B_{i,t+1}\}_{i,t}$, prices $\{P^T_{i,t}, P^N_{i,t}\}_{i,t}$ and interest rates $\{R_{i,t}\}_{i,t}$, satisfying (2), (4), (6), (7), (8), (9), (10), (11), (12), (13), (14) and standard transversality conditions, given a path for $\{\omega_{i,t}\}_{i,t}$, initial conditions $\{R_{i,-1}, B_{i,-1}, P_{i,-1}\}_i$ and $\{P_{i,t}\}_{i,t}$ set by monetary policy. In period 0 the nominal wage is fixed and equal to $W_{i,0} = 1$ for all i, while $\{W_{i,t}\}_{i,t}$ adjusts so that (14) holds with equality for $t \geq 1$. Finally, under financial autarky $C^T_{i,t} = Y^T_{i,t}$ for all i and t, while under free capital mobility $R_{i,t} = R_t$ for all i and t.

2.4 Monetary policy

We are interested in deriving the optimal non-cooperative monetary policy. We will frame monetary policy in terms of a target path for the price level $P_{i,t}$.[12] In the long run, since wages and prices are fully flexible, the optimal monetary policy targets zero inflation, so that $P_{i,t} = P_{i,t-1}$ for $t \geq 1$. In the short run, it may be optimal to deviate from this zero inflation benchmark. As we will see, a rise in $P_{i,0}$ causes a rise in short-run aggregate demand. In what follows, we will then refer to monetary interventions leading to increases in $P_{i,0}$ as monetary expansions. Symmetrically, monetary interventions causing declines in $P_{i,0}$ can be interpreted as monetary contractions.

2.5 A demand reallocation shock

We study the macroeconomic adjustment to a temporary demand reallocation shock. The economy starts from a steady state in which $\omega_{i,-1} = \omega$ in every country. In period 0 the reallocation shock hits and demand for tradables is unusually high. For most of the paper we will focus on a symmetric scenario, such that in every country $\omega_{i,0} = \omega_0 > \omega$, but we will also consider other possibilities. Thereafter, $\omega_{i,t}$ goes back to its steady state value ω in every country. The shock occurring at date 0 is previously unanticipated, but from then on agents have perfect foresight. Given these

[12] As it is standard, see for instance Galí (2009), the central bank can enforce a path for the price level by appropriately designing a rule for the policy rate $R^n_{i,t}$.

assumptions, in period $t = 1$ the economy jumps to its final steady state, in which all the variables are constant, and interest rates are given by $R^n_{i,t} = R_{i,t} = 1/\beta$.

Throughout, we consider a symmetric scenario in which all the countries start with a zero net foreign asset position ($B_{i,0} = 0$ for all i). In the initial steady state wages are flexible and firms face no capacity constraints, and so $Y^T_{i,-1} = \bar{Y}^T = \omega\bar{L}$ and $Y^N_{i,-1} = (1-\omega)\bar{L}$ for all i.[13] These assumptions, coupled with the normalisation $W_{i,-1} = 1$, imply that $P_{i,-1} = P^T_{i,-1} = P^N_{i,-1} = 1$. Hence, $P_{i,0}$ denotes both the price level and the inflation rate in period 0.

3 Optimal monetary policy under financial autarky

Let us start by deriving the optimal policy under financial autarky. In this case, no current account imbalances can arise and so $C^T_{i,t} = Y^T_{i,t}$ for all i and t. Effectively, this corresponds to a closed economy benchmark.

Under financial autarky, monetary policy actions in the short run have no impact on households' utility in the long run. The optimal monetary policy in a generic country then consists in setting $P_{i,0}$ to maximize households' utility

$$\omega_{i,0} \log Y^T_{i,0} + (1-\omega_{i,0}) \log Y^N_{i,0} - \chi\left(P_{i,0}\right), \tag{15}$$

where we have used the equilibrium conditions $C^T_{i,0} = Y^T_{i,0}$ and $C^N_{i,0} = Y^N_{i,0}$, subject to

$$P^T_{i,0} = \left(\frac{Y^T_{i,0}}{\bar{Y}^T}\right)^{\frac{1-\alpha}{\alpha}} \tag{16}$$

$$Y^N_{i,0} = \frac{1-\omega_{i,0}}{\omega_{i,0}} Y^T_{i,0} P^T_{i,0} \tag{17}$$

$$\alpha\left(Y^T_{i,0}\right)^{\frac{1}{\alpha}}\left(\bar{Y}^T\right)^{1-\frac{1}{\alpha}} + (1-\alpha)\bar{Y}^T + Y^N_{i,0} \leq \bar{L} \tag{18}$$

$$P_{i,0} = \left(P^T_{i,0}\right)^{\omega_{i,0}}. \tag{19}$$

Constraint (16) captures desired production by firms in the tradable sector, constraint (17) ensures that the output of non-traded goods is equal to households' demand, constraint (18) guarantees that firms' labor demand does not exceed households' labor supply,[14] while constraint (19) is just the definition of the short-run inflation rate. Therefore, in absence of capital mobility, the central bank's problem is fully determined by domestic variables, and does not depend on what happens

[13] To solve for equilibrium output in the initial steady state, consider that since there are no capacity constraints $Y^T_{i,-1} = L^T_{i,-1}$, $Y^N_{i,-1} = L^N_{i,-1}$, and so $P^N_{i,-1} = P^T_{i,-1} = W_{i,-1}$. Moreover, since trade is balanced (6) implies $\omega Y^N_{i,-1} = (1-\omega)Y^T_{i,-1}$. Finally, since wages are flexible $L^T_{i,-1} + L^N_{i,-1} = \bar{L}$. Combining these conditions gives $Y^T_{i,-1} = \omega\bar{L}$ and $Y^N_{i,-1} = (1-\omega)\bar{L}$.

[14] In principle, the central bank could set the inflation rate high enough so that firms' labor demand exceeds households' labor supply. However, in our framework it would never be optimal for a central bank to do so, because this policy would generate an inflation cost without any benefit in terms of higher output and consumption. We thus streamline the analysis by imposing directly constraint (18) on the central bank's problem.

in the rest of the world.

To solve this problem, let us start by deriving the policy that would keep the economy at full employment, so that constraint (18) binds. This is the case if $P_{i,0} = P_{i,0}^{fe}$, defined by

$$P_{i,0}^{fe} = \left(\frac{\omega_{i,0}}{\omega} \frac{1-\omega(1-\alpha)}{1-\omega_{i,0}(1-\alpha)} \right)^{\omega_{i,0}(1-\alpha)}, \tag{20}$$

where we have used $\bar{Y}^T = \omega \bar{L}$. From this expression, one can see that $P_{i,0}^{fe}$ is increasing in $\omega_{i,0}$. Intuitively, a higher $\omega_{i,0}$ means a higher demand for tradable goods relative to non-tradable ones. Facing lower demand, firms in the non-tradable sector fire workers, so that part of the labor force ends up being unemployed. To maintain full employment, monetary policy has to trigger an increase in the production of tradable goods, or to boost demand for non-tradable goods. It turns out that a rise in inflation, or equivalently a higher $P_{i,t}^T$, achieves both objectives. On the one hand, given that the nominal wage is fixed, a rise in $P_{i,0}^T$ induces firms in the tradable sector to hire more workers and expand production. On the other hand, a higher $P_{i,0}^T$ generates an expenditure switch away from tradable goods and toward non-tradable ones, thus sustaining employment in the non-tradable sector.

There is also a third, more subtle, effect through which a monetary expansion increases employment in the non-traded sector. As $Y_{i,0}^T$ rises, households' income increases, inducing a rise in consumers' demand. This effect is particularly strong under financial autarky. With no capital mobility, in fact, a rise in $Y_{i,0}^T$ leads to a one for one increase in $C_{i,0}^T$. As $C_{i,0}^T$ increases, also demand for non-tradable goods rises (see (6)), and so does employment in the non-traded sector. Intuitively, in a closed economy households immediately spend in consumption all the additional income coming from the increase in production of tradable goods. As we will see, this effect will be crucial in shaping the gains from international monetary coordination under financial integration.

Maintaining full employment during a demand reallocation shock thus requires a rise in inflation. Intuitively, changing quickly the economy's production mix entails productivity losses. To prevent labor demand and employment from falling, real wages have to decline. Since nominal wages are rigid, the only way for real wages to drop is through a burst of inflation. If the cost of inflation is sufficiently small, the optimal monetary policy allows sufficient inflation to maintain full employment. Otherwise, if the inflation cost linked to full employment is too high, the optimal monetary policy strikes a balance between containing inflation in the tradable sector and unemployment in the non-tradable one. In this case, a rise in $\omega_{i,0}$ acts as a cost-push shock, leading both to a rise in inflation and slack in the labor market.

More precisely, taking the first order condition with respect to $P_{i,0}$ gives that at an interior optimum

$$\chi'(P_{i,0}) P_{i,0} = \frac{1}{\omega_{i,0}} \left(\frac{\alpha}{1-\alpha} + 1 - \omega_{i,0} \right). \tag{21}$$

The left-hand side of this expression captures the marginal cost from increasing inflation, while the right-hand side captures the marginal benefit in terms of higher consumption of both tradable and non-tradable goods. Let's call $\bar{P}_{i,0}$ the value of $P_{i,0}$ that solves the equation above. It is easy to see that the optimal $P_{i,0}$ is equal to min $\left(P_{i,0}^{fe}, \bar{P}_{i,0}\right)$. This is the case because there are no gains from increasing inflation further once the economy has reached full employment. So, intuitively, under the optimal policy either the economy operates at full employment, or inflation is equal to the optimal upper bound $\bar{P}_{i,0}$. The following proposition collects these results.[15]

Proposition 1 *Under financial autarky, the optimal monetary policy response to a rise in $\omega_{i,0}$ entails a rise in inflation $P_{i,0} > 1$. Moreover, if*

$$\chi'\left(P_{i,0}^{fe}\right)P_{i,0}^{fe} \leq \frac{1}{\omega_{i,0}}\left(\frac{\alpha}{1-\alpha}+1-\omega_{i,0}\right),$$

with $P_{i,0}^{fe}$ defined by (20) then $L_{i,0} = \bar{L}$, otherwise $L_{i,0} < \bar{L}$ and $P_{i,0} = \bar{P}_{i,0}$, where $\bar{P}_{i,0}$ is implicitly defined by (21).

Figure 2 shows graphically the macroeconomic impact of a reallocation shock under financial autarky. The upward-sloped PC schedule captures the Phillips curve type of relationship between short-run inflation and firms' labor demand implied by our model, given by[16]

$$P_{i,0} = \left(\frac{\omega_{i,0}}{\omega}\frac{L_{i,0}/\bar{L}-\omega(1-\alpha)}{1-\omega_{i,0}(1-\alpha)}\right)^{\omega_{i,0}(1-\alpha)}. \tag{PC}$$

The logic behind this expression is quite different from the one underlying standard Phillips curves. In fact, our model abstracts from the standard Phillips curve transmission channel, based on the idea that higher employment leads to higher wage inflation. Instead, here inflation is positively related to employment because a higher price of the tradable good fosters labor demand in both sectors, through the three channels explained above. The MP schedule captures the monetary policy stance. Intuitively, it is optimal for central banks to tolerate any level of inflation necessary to attain full employment, as long as this is lower than the ceiling implicitly defined by expression (21).

In absence of a demand reallocation shock, i.e. if $\omega_{i,0} = \omega$, the economy operates at full employment ($L_{i,0} = \bar{L}$) and there is zero inflation ($P_{i,0} = P_{-1}$). A rise in $\omega_{i,0}$ triggers an upward shift of the PC schedule to PC$'$, because now higher inflation is needed to achieve a given level of employment. Hence, a reallocation shock corresponds to a cost push shock shifting the Phillips curve.[17] In the case shown in the figure, the shock is large enough so that the optimal monetary policy accommodates it through a rise in inflation ($P_{i,0} > P_{-1}$) and unemployment ($L_{i,0} < \bar{L}$).

Figure 3 shows, using a numerical example, the inflation and unemployment response to different values of the reallocation shock. While our model is too simple to perform a careful quantitative

[15] All the proofs can be found in Appendix A.

[16] This expression is obtained using (16), (17) and $\alpha\left(Y_{i,0}^T\right)^{\frac{1}{\alpha}}\left(\bar{Y}^T\right)^{1-\frac{1}{\alpha}} + (1-\alpha)\bar{Y}^T + Y_{i,0}^N = L_{i,0}$, as well as the definition of the price level. Notice that, since we are focusing on labor demand by firms, we don't impose the equilibrium requirement $L_{i,0} \leq \bar{L}$ when drawing the Phillips curve.

[17] The reallocation shock also induces a downward shift of the MP curve to MP$'$, because a higher $\omega_{i,0}$ reduces the ceiling on inflation imposed by the optimal monetary policy.

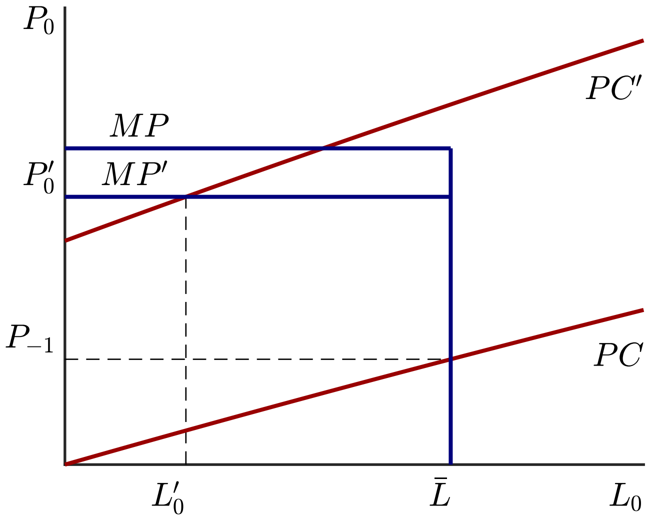

Figure 2: Macroeconomic impact of a demand reallocation shock under financial autarky.

analysis, we try to pick reasonable values for the parameters. The key parameter in our model is α, which measures the convexity of the supply curve characterizing the tradable sector. We set $\alpha = .66$, which implies that a 1% increase in $Y_{i,0}^T$ is associated with a rise in $P_{i,0}^T$ by 0.5%. This elasticity is in the ballpark of the estimates provided by Boehm and Pandalai-Nayar (2022) for sectors operating at a high level of capacity utilization.[18] For illustrative purposes, we assume a quadratic cost of inflation $\chi\left(P_{i,t}/P_{i,t-1}\right) = \bar{\chi}/2\left(P_{i,t}/P_{i,t-1} - 1\right)^2$ and set $\bar{\chi} = 350$. Finally, we assume that in the initial steady state $\omega = .3$, close to its value in the United States at the onset of the pandemic.

The solid lines in Figure 3 refer to the optimal monetary policy. If the shock is small enough, the optimal monetary policy maintains full employment. As the shock gets larger, so does the amount of inflation needed to sustain full employment. Once the shock gets too large, the cost of inflation becomes sufficiently high so that it is optimal for the central bank to allow for some unemployment. In term of quantities, the model implies that realistic values of the reallocation shock imply a significant trade off between inflation and economic slack. For instance, suppose that the share of tradables in consumptions expenditure rises from 0.3 to 0.35, roughly in line with the recent experience of the United States. Then a rise in inflation of around 2 percentage points would be needed to maintain full employment. Absent any increase in inflation, the economy would experience a large rise in unemployment of around 10 percentage points (see the dashed lines in the right panel).[19]

In this section, we have essentially extended the insights from the literature on inflation and reallocation shocks in closed economies to our setting (Olivera, 1964; Tobin, 1972; Guerrieri et al., 2021). In particular, this literature has shown that high inflation may arise during periods of

[18]For instance, Boehm and Pandalai-Nayar (2022) find an elasticity of 0.57 of prices with respect to quantity produced for sectors at the 85th percentile of the capacity utilization distribution (see Table 3 of the paper).

[19]Unemployment in our model should be broadly interpreted as a measure of economic slack, since our model abstracts from variable capital utilization and labor hoarding.

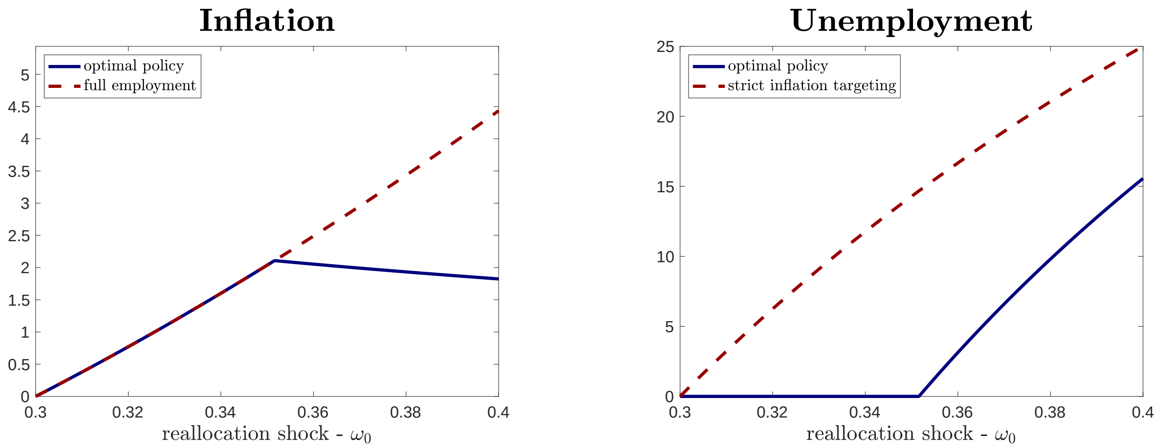

Figure 3: Inflation and unemployment response to a reallocation shock under financial autarky. Notes: solid lines represent the optimal policy, the dashed line in the left panel represents the amount of inflation needed to maintain the economy at full employment ($L_{i,0} = \bar{L}$), while the dashed line in the right panel represents the unemployment associated with a policy of strict inflation targeting ($P_{i,0} = P_{i,-1}$).

sectoral reallocation, even in absence of overheating on the labor market. While this point is well understood, little is known about what happens when reallocation shocks take place in a financially integrated world, and whether in this case coordination failures among national central banks may arise. We tackle these issues next.

4 Optimal monetary policy with free capital mobility

Capital mobility allows countries to run trade imbalances, so domestic consumption of tradable goods may deviate from domestic production in the short run.

Lemma 1 *Under free capital mobility, short-run consumption of tradable goods is equal to*

$$C_{i,0}^T = \frac{\omega_{i,0}}{\omega_{i,0}(1-\beta)+\beta}\left(Y_{i,0}^T(1-\beta)+\frac{\bar{Y}^T}{\omega R_0}\right). \tag{22}$$

Intuitively, in the short run households consume a fraction of the present value of the country's expected stream of tradable output. If consumption exceeds current output, the country finances the gap by running a current account deficit. Holding everything else constant, a higher preference for tradable consumption, i.e. a higher $\omega_{i,0}$, drives up short-run consumption of tradables and the trade deficit. A rise in R_0, instead, reduces $C_{i,0}^T$ and the trade deficit, because a higher world interest rate increases the cost of borrowing to consume.

The optimal policy problem is now slightly complicated by the fact that monetary interventions in the short run may affect the country's stock of net foreign assets and consumption in the long run. In Appendix A.3, we show the central bank's problem with free capital mobility amounts to setting $P_{i,0}$ to maximize

$$\left(\omega_{i,0} + \frac{\beta}{1-\beta}\right) \log C_{i,0}^T + (1 - \omega_{i,0}) \log Y_{i,0}^N - \chi\left(P_{i,0}\right), \tag{23}$$

subject to constraints (16), (18), (19), (22) and

$$Y_{i,0}^N = \frac{1-\omega_{i,0}}{\omega_{i,0}} C_{i,0}^T P_{i,0}^T. \tag{24}$$

The key difference with respect to the case of financial autarky is that now $C_{i,0}^T$ may deviate from $Y_{i,0}^T$, and that the path of tradable consumption is dictated by households' saving decisions, as captured by constraint (22). Since tradable consumption depends on the world interest rate, there is now a link between the optimal policy problem and external factors.

Throughout this section, we will focus on non-cooperative Nash equilibria. In our model, this implies that national central banks set monetary policy taking the path of the world interest rate as given. The reason is that each country is infinitesimally small, and so the impact of its monetary policy actions on the rest of the world is negligible. In the scenarios that we will consider $R_0 \geq 1/\beta$, and hence we impose this condition from now on.

As before, it may be optimal for the central bank to maintain the economy at full employment. This is the case if $P_{i,0} = P_{i,0}^{fe}$, which is now implicitly defined by

$$P_{i,0}^{fe} = \left(\frac{\omega_{i,0}}{\omega} \frac{\alpha\omega + 1 - \omega}{\alpha\omega_{i,0} + (1-\omega_{i,0}) \frac{C_{i,0}^T}{Y_{i,0}^T}}\right)^{\omega_{i,0}(1-\alpha)}. \tag{25}$$

If the inflation cost is high enough, instead, the optimal monetary response to the reallocation shock entails a rise in unemployment. Taking the first order condition with respect to $P_{i,0}$ gives that at an interior optimum

$$\chi'\left(P_{i,0}\right) P_{i,0} = \frac{1}{\omega_{i,0}} \left(\frac{\alpha}{1-\alpha} \frac{\omega_{i,0}}{\omega_{i,0} + \beta(1-\omega_{i,0})} \frac{Y_{i,0}^T}{C_{i,0}^T} + 1 - \omega_{i,0}\right). \tag{26}$$

It turns out that both sides of equation (26) are increasing in $P_{i,0}$, meaning that in principle multiple values of $P_{i,0}$ may solve it. From now on, we will assume that conditions are such that at most one solution to (25) satisfies $P_{i,0} \leq P_{i,0}^{fe}$.[20] Then, defining by $\bar{P}_{i,0}$ the smallest value of $P_{i,0}$ that solves (26), the optimal monetary policy sets $P_{i,0} = \min\left(P_{i,0}^{fe}, \bar{P}_{i,0}\right)$.

Proposition 2 *Assume that $R_0 \geq 1/\beta$ and that parameters are such that at most one solution to (26) satisfies $P_{i,0} \leq P_{i,0}^{fe}$. Then, under free capital mobility the optimal monetary policy sets $P_{i,0} = \min\left(P_{i,0}^{fe}, \bar{P}_{i,0}\right) \geq 1$, where $P_{i,0}^{fe}$ solves (25), while $\bar{P}_{i,0}$ is the smallest value of $P_{i,0}$ that solves*

[20]This property holds in all the numerical simulations that we have tried. In fact, while we were able to find some parametrizations under which (26) has multiple solutions, we also found that every solution except the smallest one is associated with implausibly high levels of inflation, violating constraint (18).

(26).

Before moving on, let us observe that in open economies trade imbalances and capital flows affect the trade off between inflation and employment faced by national central banks. This can be seen by deriving the open-economy version of the Phillips curve[21]

$$P_{i,0} = \left(\frac{\omega_{i,0}}{\omega} \frac{L_{i,0}/\bar{L} + (1-\alpha)\omega}{\alpha\omega_{i,0} + (1-\omega_{i,0}) \frac{C^T_{i,0}}{Y^T_{i,0}}} \right)^{\omega_{i,0}(1-\alpha)}. \tag{PC}$$

This expressions implies that an increase in the trade deficit, i.e. a rise in $C^T_{i,0}/Y^T_{i,t}$, allows a country to achieve a higher level of employment for given inflation. Intuitively, trade deficits sustain short-run consumption of tradables. In turn, higher consumption of tradables boosts demand for non-tradable goods, and so employment in the non-traded sector. Because of this effect, capital inflows effectively act as a positive cost-push shock, ameliorating the trade off between inflation and employment faced by the central bank. Conversely, capital outflows and trade surpluses act as an adverse cost-push shock, worsening the trade off between inflation and employment. Through these effects, as it will become clear shortly, trade imbalances and capital flows play a key role in the international transmission of inflation and economic activity.

We are now ready to derive the implications of capital mobility for the macroeconomic adjustment to a reallocation shock. As an intermediate step, we will first consider a reallocation shock occurring in a single country. We will then turn to the case of a global reallocation shock.

4.1 An idiosyncratic reallocation shock

Let us start by considering a case in which the reallocation shock hits a single small open economy. Since the rest of the world is unaffected, the global interest rate remains equal to its steady state value, and $R_0 = 1/\beta$. According to (22), consumption of tradable goods then rises in the country affected by the shock. Part of the increase in tradable consumption is satisfied through higher imports, so that the country accommodates the reallocation shock by running a trade balance deficit financed with capital inflows.

Lemma 2 *Under free capital mobility, a country hit by an idiosyncratic reallocation shock runs a trade deficit in the short run* ($C^T_{i,0} > Y^T_{i,0}$).

An interesting observation is that trade deficits reduce the inflation needed to achieve full employment. Equation (25), in fact, implies that $P^{fe}_{i,0}$ is decreasing in $C^T_{i,0}/Y^T_{i,0}$. As explained above, this happens because capital inflows increase demand for non-traded goods and employment in the non-traded sector.

[21] This expression is obtained using (16), (24) and $\alpha \left(Y^T_{i,0}\right)^{\frac{1}{\alpha}} \left(\bar{Y}^T\right)^{1-\frac{1}{\alpha}} + (1-\alpha)\bar{Y}^T + Y^N_{i,0} = L_{i,0}$, as well as the definition of the price level.

If the optimum is interior, instead, monetary policy is described by expression (26). Comparing this expression with (21) shows that capital mobility reduces the marginal welfare cost associated with a drop in inflation. This difference is due to two distinct effects. First, since trade deficits reduce the scarcity of tradable goods, the welfare impact of lower production of tradables caused by a disinflation is now smaller. This effect is captured by the term $Y_{i,0}^T/C_{i,0}^T$.

The second, and most interesting, effect arises because under free capital mobility containing inflation has a smaller cost in terms of lower domestic employment. Recall that lower inflation reduces domestic production of tradable goods. In closed economies, domestic consumption of tradables falls one-for-one with domestic production. In open economies, instead, tradable consumption is less sensitive to drops in domestic tradable output. In fact, differentiating (22) gives

$$\frac{\partial C_{i,0}^T}{\partial Y_{i,0}^T} = \frac{\omega_{i,0}(1-\beta)}{\omega_{i,0}(1-\beta)+\beta} < 1.$$

This happens because households react to monetary contractions by increasing external borrowing. Moreover, since $C_{i,0}^N$ is proportional to $C_{i,0}^T$, capital inflows mitigate the negative impact of lower inflation on domestic demand for non-tradables and on employment in the non-traded sector. Therefore, from the perspective of individual countries, containing inflation entails a lower sacrifice ratio - i.e. a lower cost in terms of foregone employment and output - if capital is mobile. This effect is captured by the term $\frac{\omega_{i,0}}{\omega_{i,0}(1-\beta)+\beta} < 1$ in expression (26).

Taking stock, trade deficits lower the inflation rate associated with a given level of employment. Moreover, capital mobility reduces the sensitivity of output to changes in inflation. Both effects mitigate the rise in inflation triggered by an idiosyncratic reallocation shock.[22] The impact of capital mobility on employment is instead ambiguous. On the one hand, lower inflation points toward lower employment. On the other hand, capital inflows increase the employment rate associated with a given level of inflation. If the second force dominates, openness to capital flows leads to both lower inflation and higher employment in periods of unbalanced demand.

Figure 4 shows these results graphically.[23] The first thing to notice is that the Phillips curve under free capital mobility (PC^f) is steeper than in a financially-closed economy (PC^a), because - as we have just seen - capital mobility reduces the negative impact of lower inflation on domestic employment. This also explains why under free capital mobility central banks impose a lower inflation ceiling (compare MP^f with MP^a). However, under free capital mobility a given reallocation shock induces a smaller shift of the PC curve, because trade deficits mitigate the endogenous cost

[22] Seen through the lens of these results, the trade deficits run by the United States during the recovery from the Covid recession helped to contain US inflation. This result is also related to an old view, very well exemplified by Sachs (1985), stating that the combination of trade deficits and strong dollar facilitated the 1980s disinflation in the United States. Sachs (1985) also argued that these same factors exported inflation from the United States toward the rest of the world. As we will see, our model rationalizes this insight.

[23] To derive the PC and MP curves under financial integration, we have used the fact that the trade deficit is determined by

$$\frac{C_{i,0}^T}{Y_{i,0}^T} = \frac{\omega_{i,0}}{\omega_{i,0}+(1-\beta)+\beta}\left(1-\beta+\frac{\beta}{\omega}P_{i,0}^{-\frac{\alpha}{\omega_{i,0}(1-\alpha)}}\right).$$

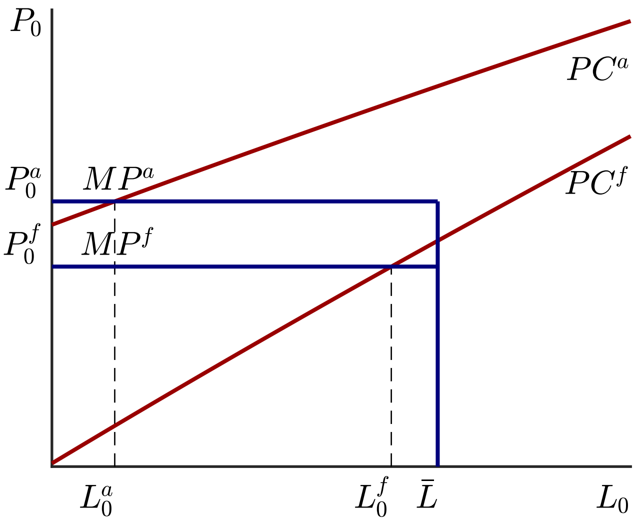

Figure 4: Macroeconomic impact of an idiosyncratic reallocation shock: financial autarky vs. free capital mobility.

push shock associated with the rise in demand for tradable goods relative to non-tradable ones. As a result, under free capital mobility an idiosyncratic reallocation shock may generate not only a smaller rise in inflation ($P_0^f < P_0^a$), but also higher employment ($L_0^f > L_0^a$).

Figure 5, which is based on our numerical example, paints a similar picture.[24] First, capital mobility mitigates substantially the rise in inflation caused by the reallocation shock. Moreover, if the shock is sufficiently severe, capital mobility is associated with a significantly milder increase in unemployment. For instance, consider again a rise in $\omega_{i,0}$ from 0.3 to 0.35. Then, with respect to financial autarky, capital mobility reduces the rise in inflation by around 1 percentage point, without any appreciable difference in unemployment. Summing up, international financial integration facilitates the macroeconomic adjustment to idiosyncratic reallocation shocks. But what if the reallocation shock is global?

4.2 A global reallocation shock

We now turn to a global reallocation shock, i.e. a synchronized rise in $\omega_{i,0}$ affecting every country in the world (so that $\omega_{i,0} = \omega_0 > \omega$ for all i). As global demand for tradables rises, all the countries seek to run a trade deficit by borrowing from the rest of the world. In response, the world interest rate increases until equilibrium on the global credit markets is restored. Since all the countries are symmetric, this happens when trade is balanced, so that every country consumes exactly its production of tradable goods.

As in the case of an idiosyncratic shock, the optimal monetary policy is characterized by expressions (25) and (26), but with the twist that in equilibrium $C_{i,0}^T = Y_{i,0}^T$. The first implication is that $P_{i,0}^{fe}$ now coincides with the one under financial autarky. The degree of capital mobility

[24] To draw this picture, we set $\beta = .99$ to target a yearly steady interest rate of $R = 1/\beta = 1.01$, and keep all the other parameters as in Section 3.

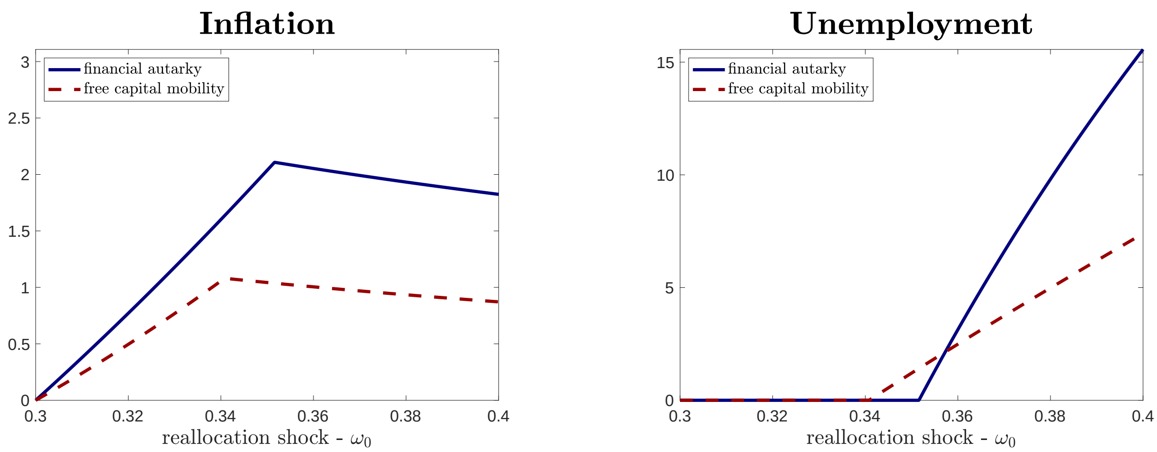

Figure 5: Inflation and unemployment response to an idiosyncratic reallocation shock. Notes: solid lines refer to the optimal monetary policy response under financial autarky. Dashed lines refer to the optimal monetary policy response under free capital mobility.

thus does not affect the amount of inflation needed to sustain full employment during a global reallocation shock.

This does not mean, however, that monetary policy is unaffected by international financial integration. Even during a global reallocation shock, in fact, free capital mobility reduces the marginal benefit attached by national central banks to a rise in inflation. This can be seen by comparing (21) and (26), evaluated at $C^T_{i,0} = Y^T_{i,0}$. As explained above, financial integration weakens the positive impact of higher inflation on domestic demand and employment, because households end up saving most of the increase in income associated with a rise in the domestic production of tradable goods. Therefore, capital mobility may induce central banks to adopt a more contractionary monetary stance in times of unbalanced global demand.

Proposition 3 *Consider a global reallocation shock, i.e.* $\omega_{i,0} = \omega_0 > \omega$ *for all* i*. Under free capital mobility, the optimal monetary policy response to a rise in* ω_0 *entails a rise in inflation* $P_{i,0} > 1$*. Moreover, if*

$$\chi'\left(P_0^{fe}\right)P_0^{fe} \leq \frac{1}{\omega_0}\left(\frac{\alpha}{1-\alpha}\frac{\omega_0}{\omega_0+\beta(1-\omega_0)}+1-\omega_0\right), \tag{27}$$

with P_0^{fe} *defined by* (20) *then* $L_{i,0} = \bar{L}$ *and the allocation coincides with the one under financial autarky. Otherwise* $L_{i,0} < \bar{L}$*, and the allocation under free capital mobility is characterized by lower inflation and lower employment compared to the one under financial autarky.*

Figure 6 illustrates this result. In a symmetric equilibrium, the degree of capital mobility does not affect the relationship between *global* inflation and *global* employment captured by the PC curve. It does, however, affect monetary policy. In fact, from the perspective of national central banks free capital mobility worsens the trade off between *domestic* inflation and *domestic* employment, by steepening the country-level Phillips curve. This effect explains why the inflation

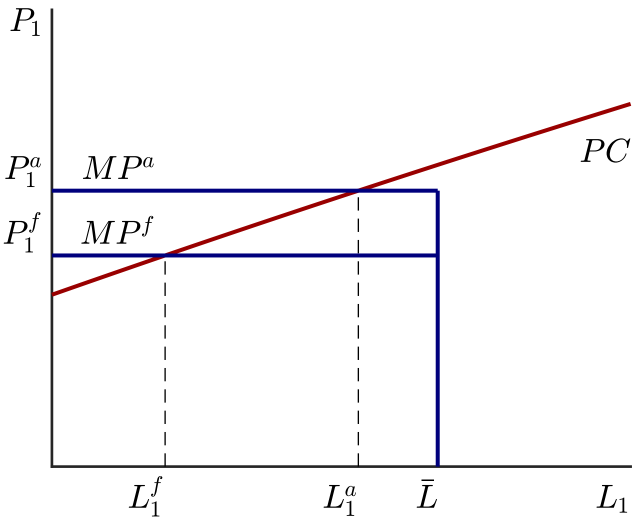

Figure 6: Macroeconomic impact of a global reallocation shock: financial autarky vs. free capital mobility

ceiling imposed by central banks is lower under free capital mobility (MP^f schedule) compared to financial autarky (MP^a schedule). As a result, free capital mobility may reduce the impact of a reallocation of global expenditure toward tradable goods on inflation ($P_0^f < P_0^a$), but at the cost of higher unemployment ($L_0^f < L_0^a$).

Figure 7 further clarifies this result. If the shock is small enough, regardless of whether capital is mobile or not, it is optimal for national central banks to maintain full employment. In this case, financial openness does not affect the inflation and unemployment response to a global rise in demand for tradables. If the shock is large enough, however, the monetary response under financial integration is characterized by lower inflation and higher unemployment. For instance, compared to financial autarky, when $\omega_{i,0} = .35$ central banks choose to reduce inflation by around one percentage point, even though this entails a rise in unemployment to almost 10 percent.[25] Free capital mobility is thus associated with a deflationary bias during periods of buoyant demand for tradable goods relative to non-tradable ones.

5 International spillovers and gains from cooperation

We are now ready to address one of the fundamental questions of the paper: are there gains from coordinating national monetary interventions? It turns out that the answer is a qualified yes. Under certain circumstances, indeed, lack of monetary coordination may lead to an excessively sharp global slump in times of unbalanced global demand. As we will see, this is due to the fact that national central banks do not internalize the international spillovers triggered by their actions.

[25] In our model, all the agents have access to international credit markets. Though we have not proven this result formally, we conjecture that the distance between the financial autarky equilibrium and the free capital mobility one would be smaller if only part of the households participated in international financial transactions. This would be the case, for instance, if some hand-to-mouth agents were present.

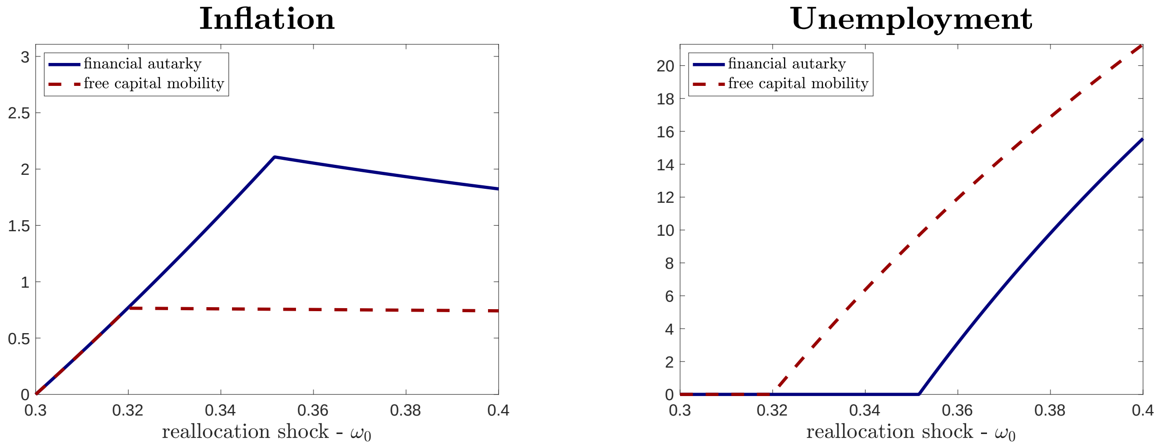

Figure 7: Inflation and unemployment response to a global reallocation shock. Notes: solid lines refer to the optimal monetary policy response under financial autarky. Dashed lines refer to the optimal monetary policy response under free capital mobility.

5.1 Optimal monetary policy with international cooperation

Let us start by deriving the optimal monetary policy under international cooperation. Imagine that monetary policy is set by a global central bank maximizing global welfare, simply defined as the sum of the lifetime utility enjoyed by every world citizen.[26] The global central bank sets $P_{i,0}$ in every country i, and is subject to the same constraints imposed on national central banks. The difference is that the global central bank internalizes the impact of its actions on the world interest rate R_0.

We will focus on symmetric equilibria, and in particular on a global reallocation shock. Since all the countries are identical, in period 0 the world interest rate is[27]

$$R_0 = \frac{\bar{Y}^T}{\beta Y_0^T}\frac{\omega_0}{\omega}, \tag{28}$$

where $Y_0^T \equiv \int_0^1 Y_{i,0}^T di = Y_{i,0}^T$. Plugging this expression in constraint (22) shows that the problem of the global central bank is isomorphic to the one of national central banks under financial autarky. So the optimal cooperative monetary policy response to a global reallocation shock is identical to the one chosen by national central banks in closed economies.

What are the implications for international monetary cooperation? Trivially, in closed economies there is no scope for cooperation. A look back at Proposition 3, however, reveals that gains from cooperation may arise under free capital mobility.

[26]More formally, global welfare is defined as

$$\int_0^1 \sum_{t=0}^{\infty} \beta^t \left(\log\left(C_{i,t}\right) - \chi\left(\frac{P_{i,t}}{P_{i,t-1}}\right)\right) di.$$

[27]To derive this expression, we have used the fact that in a symmetric equilibrium the final steady state is equal to the initial one. Hence, $C_{i,1}^T = Y_{i,1}^T = \bar{Y}^T$. Plugging this condition in the households' Euler equation (4) gives (28).

Corollary 1 (Corollary to Proposition 3) *Consider a global demand reallocation shock. Then the uncooperative Nash equilibrium coincides with the cooperative one if and only if* (27) *holds.*

There are two cases to consider. First, imagine that national central banks choose to maintain full employment ($L_{i,t} = \bar{L}$). This is the case if condition (27) holds. Then, even absent international cooperation, the monetary stance implemented by national central banks is optimal from a global perspective.

But now consider a scenario in which condition (27) is violated, so that national central banks sacrifice full employment to contain inflation ($L_{i,t} < \bar{L}$). Then the policy implemented by self-oriented national central banks suffers from a deflationary bias, which leads to an excessive global slump. Why are national central banks choosing an excessively contractionary monetary stance? To answer this question, we turn to the international spillovers triggered by monetary interventions.

5.2 International spillovers, capital flows, and competitive appreciations

Perhaps the best way to understand how international spillovers operate is to start from the open-economy Phillips curve, which we rewrite here for convenience

$$P_{i,0} = \left(\frac{\omega_{i,0}}{\omega} \frac{L_{i,0}/\bar{L} + (1-\alpha)\omega}{\alpha\omega_{i,0} + (1-\omega_{i,0})\frac{C^T_{i,0}}{Y^T_{i,0}}} \right)^{\omega_{i,0}(1-\alpha)}. \tag{PC}$$

This expression shows how global factors, encapsulated by the trade deficit term $C^T_{i,0}/Y^T_{i,0}$, shift around the Phillips curve. For instance, consider a global shock generating a rise in the world interest rate R_0. Agents in country i react by decreasing their consumption of tradable goods, leading to a drop in the trade deficit $C^T_{i,0}/Y^T_{i,0}$ (see (22)). In turn, a lower trade deficit depresses demand for domestic non-traded goods, meaning that now more inflation is needed to achieve a given level of employment. Global shocks increasing the world interest rate thus cause higher inflation, and potentially higher unemployment, in country i. The opposite logic applies to global factors depressing the world interest rate.

Let us now consider an asymmetric reallocation shock, such that $\omega_0 > \omega$ everywhere except for country i (i.e. $\omega_{i,0} = \omega$). We have already argued that a temporary rise in the global demand for tradables pushes up the equilibrium world interest rate R_0.[28] How is country i affected? First, a higher R_0 induces country i to run a trade surplus and experience capital outflows. Moreover, due to the logic spelled out above, capital outflows cause an exchange rate depreciation and a rise in inflation in country i. Hence, high global demand for tradables is inflationary also in those

[28] More formally, expression (28) implies that during a global reallocation shock R_0 is decreasing in Y^T_0. So R_0 reaches its minimum when central banks target full employment and

$$R_0 = \frac{1}{\beta}\left(\frac{\omega_0}{\omega}\right)^{1-\alpha}\left(\frac{1-\omega_0(1-\alpha)}{1-\omega(1-\alpha)}\right)^{\alpha}.$$

The right-hand side of this expression is increasing in ω_0, implying that if $\omega_0 > \omega$ then $R_0 > 1/\beta$.

countries not directly affected by the shock.[29]

Now consider a scenario in which every country in the world, except for country i, implements a monetary contraction. The global monetary contraction causes a drop in P_0^T and in the global supply of traded goods Y_0^T. By equation (28), the world interest rate R_0 then rises. But a higher R_0 acts as a negative cost-push shock in country i. Through this channel, perhaps surprisingly, a monetary contraction abroad leads to higher inflation in country i. During times of high global demand for tradables, therefore, inflation rates are strategic substitutes across countries.

The gains from cooperation arise precisely because - due to a coordination failure - national central banks do not internalize these negative international spillovers. To see this point, start from the optimal cooperative monetary policy. Now let national central banks choose unilaterally their preferred monetary stance, so as to reach the Nash equilibrium. If national central banks find in their best interest to maintain full employment - i.e. if condition (27) holds - lack of coordination does not undermine the cooperative equilibrium.

But if condition (27) is violated, the cooperative equilibrium unravels as monetary authorities embark on an inefficient monetary contraction. Each central bank, in fact, seeks to reduce domestic inflation - while incurring a small cost in terms of lower output - by hiking its policy rate to attract capital inflows. However, since all the countries behave symmetrically, the synchronized monetary contraction has no impact on capital flows in equilibrium. All that is left is an excessively tight monetary policy, causing an unnecessarily sharp global economic slump. These negative outcomes would be avoided if national central banks correctly internalized the global output losses associated with their disinflationary policies. But they don't, because part of the output losses caused by a domestic disinflation are exported abroad.

Effectively, cooperation breaks down because self-oriented national central banks engage in competitive appreciations. In fact, recall that the exchange rate in country i is equal to

$$S_{i,t} = \frac{P_{i,t}^T}{P_t^T},$$

where P_t^T is the average price of the traded good in the rest of the world. If (27) is violated, the cooperative equilibrium cannot be sustained because each central bank tries to disinflate by appreciating its currency, i.e. by pushing the domestic price of tradables below the one of its trading partners. However, the effort to appreciate the exchange rate is frustrated by the fact that all the countries in the world implement a synchronous monetary contraction.

We find this result particularly intriguing, because it contrasts with the notion of competitive depreciations. When countries engage in competitive depreciations, they seek to attract foreign demand and sustain domestic employment by depreciating their exchange rate. Competitive depreciations, however, are typically an issue during periods of weak global demand and low inflation, such as the Great Depression or the aftermath of the 2008 global financial crisis.[30] We study a dif-

[29]This logic suggests that, during the recovery from Covid-19, high consumption of tradable goods by the United States and the associated US trade deficits increased inflationary pressures in the rest of the world.

[30]See Caballero et al. (2021), Eggertsson et al. (2016) and Fornaro and Romei (2019) for models capturing the

ferent scenario, characterized by global scarcity of tradable goods and high inflation. This explains why in our model competitive appreciations pose a challenge to international cooperation.[31]

6 Some further considerations

Having established our main result, we now discuss a few other implications of our model.

6.1 Policy rates

So far we have framed monetary policy in terms of targeting rules for inflation and employment. We now describe how policy rates react to a global reallocation shock. Combining the households' optimality conditions, one can see that in a symmetric equilibrium policy rates evolve according to[32]

$$R_{i,0}^n = \frac{1}{\beta}\frac{C_{i,1}}{C_{i,0}}\frac{P_{i,1}}{P_{i,0}} = \frac{1}{\beta}\frac{\omega_0}{\omega}\left(\frac{\bar{Y}^T}{Y_0^T}\right)^{\frac{1-\omega_0(1-\alpha)}{\alpha}}$$

A rise in ω_0 thus puts upward pressure on nominal rates. Intuitively, a rise in ω_0 creates excess demand on the global market for tradables. Now imagine for a second that central banks seek to fully stabilize inflation, so that Y_0^T does not react to the reallocation shock. In this case, policy rates have to rise, so as to cool down demand and restore equilibrium on the global market for tradables.

In reality, as we have shown, it is optimal for central banks to let Y_0^T rise in reaction to a global reallocation shock. For this reason, the rise in the policy rate is milder than what would occur under a strict inflation targeting regime. That said, one can show that a global reallocation shock is always associated with a rise in policy rates.[33]

Figure 8 show the behavior of policy rates in our running numerical example. Interestingly, in this case the response of nominal rates is non-linear in the reallocation shock. For mild shocks, such that it is optimal to maintain the economy at full employment, nominal policy rates barely react. Large reallocation shocks, however, are associated with a sharp rise in nominal interest rates. The figure also shows that lack of cooperation leads central banks to implement an excessively tight

gains from cooperation in times of weak global demand.

[31]Along related lines, Frankel (2022) highlights the risk that the ongoing disinflation process may lead to competitive appreciations and reverse currency wars. Obstfeld (2022) expresses similar concerns.

[32]To derive the second equality, we have used $P_{i,1} = P_{i,0}$, as well as the fact that in a symmetric equilibrium $C_{i,1} = \bar{L}$ and

$$C_{i,0} = \frac{1}{\omega_{i,0}}\left(Y_{i,0}^T\right)^{\frac{1-\omega_0(1-\alpha)}{\alpha}}\left(\bar{Y}^T\right)^{\frac{\alpha-1}{\alpha}(1-\omega_0)}.$$

[33]To prove this result, consider that policy rates reach their minimum when the economy operates at full employment. In this case, the nominal rate is equal to

$$R_{i,0}^n = \frac{1}{\beta}\left(\frac{\omega_0}{\omega}\right)^{\omega_0(1-\alpha)}\left(\frac{1-\omega_0(1-\alpha)}{1-\omega(1-\alpha)}\right)^{1-\omega_0(1-\alpha)}.$$

Differentiating this expression with respect to ω_0, one can see that the policy rate consistent with full employment is increasing in ω_0. Since $R_{i,0}^n$ is equal to its steady state value for $\omega_0 = \omega$, this proves that policy rates rise in response to a global reallocation shock.

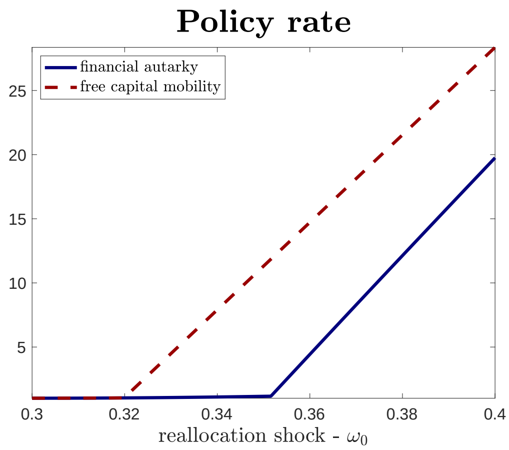

Figure 8: Response of nominal policy rates to a global reallocation shock. Notes: solid lines refer to the optimal monetary policy response under financial autarky. Dashed lines refer to the optimal monetary policy response under free capital mobility.

monetary policy, when the reallocation shock is large enough.

6.2 The profit share

How does the distribution of income between profits and labor react to a global reallocation shock? Let's start by computing the profit share of GDP. In the initial steady state, as well as in the long run, perfect competition drives profits to zero. However, in the short run firms in the tradable sector may earn profits. The profit share in period $t = 0$ is given by

$$\frac{P_{i,0}^T Y_{i,0}^T - W_{i,0} L_{i,0}^T}{P_{i,0}^T Y_{i,0}^T + P_{i,0}^N L_{i,0}^N} = \omega_0 (1 - \alpha) \left(1 - \left(\frac{\bar{Y}^T}{Y_{i,0}^T} \right)^{\frac{1}{\alpha}} \right).$$

This expression encapsulates the two channels through which a reallocation shock affects the profit share. The first one, rather mechanical, is captured by the term ω_0. Since firms in the non-traded sector earn no profits, the profit share rises with the share of tradables in consumption.

The second effect depends on the endogenous monetary policy response. In our model the profit share within the tradable sector is increasing in $Y_{i,0}^T/\bar{Y}^T$. Because of this reason, during a reallocation shock inflation is positively correlated with the profit share. This is interesting because the ongoing burst of inflation has been associated - so far - with a rise in the profit share both in the United States and in the euro area (Lane, 2023).

6.3 Wages and prices during the disinflation phase

We have already shown that real wages decline when demand reallocates. But what happens next? In our framework, once the shock abates real wages fully recover their value in the initial steady state.[34] The demand reallocation shock is thus followed by a period in which nominal wages grow

[34] In reality, part of the decline in real wages caused by the reallocation shock may become permanent. For instance, this would happen if the demand reallocation shock was associated with a drop in investment, hurting

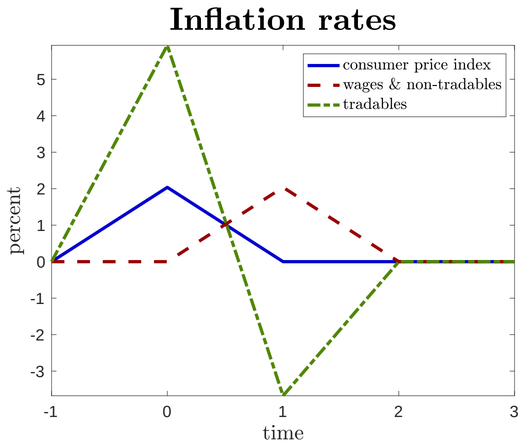

Figure 9: Inflation dynamics around a global demand reallocation shock. Notes: solid line refers to CPI inflation ($P_{i,t}/P_{i,t-1}$). Dashed line refers to wage inflation ($W_{i,t}/W_{i,t-1}$), which is equal to inflation in the non-traded sector ($P^N_{i,t}/P^N_{i,t-1}$). Dash-dotted line refers to inflation in the traded sector ($P^T_{i,t}/P^T_{i,t-1}$).

faster than prices, so that real wages regain the ground lost during the shock period.

Since prices in the non-tradable sector are equal to wages, this reasoning implies that sectoral inflation evolves according to

$$\frac{W_{i,1}}{W_{i,0}} = \frac{P^N_{i,1}}{P^N_{i,0}} > 1 > \frac{P^T_{i,1}}{P^T_{i,0}}.$$

In words, the disinflation that follows the period of the shock is driven by a drop in tradable inflation below its steady state value. Inflation in the non-traded sector, instead, overshoots its long-run value in period $t = 1$. This adjustment is needed so that relative prices go back to their steady state value.

Figure 9 displays the inflation dynamics around a global reallocation shock. To draw this figure, we have assumed that $\omega_0 = 0.35$, that monetary policy maintains full employment $L_0 = \bar{L}$, and kept all the other parameters as in our running numerical example. The figure shows that the shock period ($t = 0$) is characterized by a sharp rise in inflation in the traded sector. During the disinflation, i.e. in $t = 1$, wage and non-tradable price inflation overshoot their long-run value, while the tradable sector experiences a period of deflation. Interestingly, consistent with these predictions, both in the United States and in the euro area the recent burst of inflation originated in the goods sector, and only later migrated to wages and to the service sector (Lane, 2023).

6.4 Supply disruptions

Since the start of the pandemic, the global economy has been harmed by several negative supply shocks - hitting particularly hard the tradable sector. First, the pandemic itself disrupted global supply chains and hampered international trade. Second, Russia's invasion of Ukraine caused a

future productivity growth. Benigno and Fornaro (2018) and Fornaro and Wolf (2023) provide frameworks in which temporary shocks may persistently affect real wages through this channel.

sharp spike in energy prices, disrupting production in the energy-intensive manufacturing sector.[35] Motivated by these facts, in this section we study the economy's response to a negative productivity shock affecting the tradable sector. As we will see, many of the insights that we derived for demand reallocation shocks also apply to this alternative disturbance. This result is not surprising, once one realizes that tradable-biased supply disruptions - just like surges in demand for tradables - generate global scarcity of traded goods.

To introduce supply shocks, we replace the production function in the tradable sector with

$$Y_{i,0}^T = \left(\frac{L_{i,0}^T - (1-\alpha)\xi \bar{Y}^T}{\alpha \xi \bar{Y}^T} \right)^{\alpha} \xi \bar{Y}^T.$$

The parameter ξ determines productivity in the tradable sector in the short run. When $\xi < 1$ the tradable sector is hit by a supply disruption driving productivity below its steady state value. Profit maximization gives the pricing function

$$P_{i,0}^T = W_{i,0} \left(\frac{Y_{i,0}^T}{\xi \bar{Y}^T} \right)^{\frac{1-\alpha}{\alpha}}.$$

So a fall in ξ - holding everything else constant - causes a rise in the price of tradables. Intuitively, lower productivity increases marginal costs and induces firms to charge higher prices.

We study a global supply disruption, i.e. a scenario in which every country is identical and ξ unexpectedly falls below 1 in period $t = 0$. To isolate the impact of this negative supply shock, we abstract from demand reallocation by setting $\omega_{i,0} = \omega$. Since the analysis is very similar to what we have already seen, in this section we limit ourselves to sketch out a few results.

Financial autarky. The optimal monetary policy problem under financial autarky is identical to the one derived in Section 3, with the exception that the term $\bar{Y}^T$ in constraints (16) and (18) is replaced by $\xi \bar{Y}^T$. The Phillips curve, which recall we define as the relationship between firms' labor demand and inflation, now takes the form

$$P_{i,0} = \left(\frac{L_{i,0}/(\xi \bar{L}) - \omega(1-\alpha)}{1 - \omega(1-\alpha)} \right)^{\omega(1-\alpha)}. \tag{29}$$

A drop in ξ thus acts as a negative cost-push shock, worsening the trade off between inflation and employment faced by monetary authorities. The reason is simple. Lower productivity drags profits in the tradable sector down. To prevent a reduction in employment real wages need to fall to restore profitability.[36] Since nominal wages are rigid, a drop in real wages can only be attained through a rise in inflation.

[35] Of course, high energy prices have broader implications for to economy, besides disrupting production in the manufacturing sector. See Auclert et al. (2023) for an interesting recent paper studying several channels through which a rise in the price of energy affects open economies.

[36] Even though the supply disruption hits exclusively the tradable sector, it may lead to a decline in employment in the non-traded sector too. In fact, lower economic activity in the tradable sector decreases households' income, and so their demand for non-traded goods. In turn, lower demand leads to a reduction in production and employment in the non-traded sector. A tradable-biased supply disruption thus depresses firms' demand for labor in both sectors.

If the inflation cost is small enough, the central bank chooses to maintain full employment by setting $P_{i,0}$ equal to

$$P_{i,0}^{fe} \equiv \left(\frac{1/\xi - \omega(1-\alpha)}{1-\omega(1-\alpha)}\right)^{\omega(1-\alpha)}. \tag{30}$$

Otherwise, it is optimal to equate the marginal welfare benefit from a rise in inflation to its marginal cost

$$\chi'\left(P_{i,0}\right) P_{i,0} = \frac{1}{\omega}\left(\frac{\alpha}{1-\alpha} + 1 - \omega\right). \tag{31}$$

The optimal monetary policy then consists in setting $P_{i,0} = \min\left(P_{i,0}^{fe}, \bar{P}_{i,0}\right)$, where $\bar{P}_{i,0}$ is the value of $P_{i,0}$ that solves equation (31).

Similar to a demand reallocation shock, a tradable-biased supply disruption thus causes a rise in inflation, and possibly a fall in employment.[37] The only substantial difference is that while a rise in ω_0 leads to an increase in employment and production in the tradable sector, after a drop in ξ production and employment in the traded sector contract.

Free capital mobility. With capital mobility, every country tries to smooth out the impact of the transitory negative productivity shock on consumption by borrowing from abroad, so as to run a trade deficit. However, in a symmetric equilibrium trade imbalances cannot arise. Instead, the world interest rate rises until the balanced-trade equilibrium - in which every country consumes exactly its own production of traded goods - is restored.

The implications for monetary policy are in line with those derived in Section 4.2. That is, capital mobility does not affect the amount of inflation needed to maintain full employment, which is still given by expression (30). But capital mobility reduces the marginal benefit attached by central banks to a rise in inflation, because access to international credit markets weakens the impact of higher inflation on domestic demand and employment. In fact, with free capital mobility condition (31) is replaced by

$$\chi'\left(P_{i,0}\right) P_{i,0} = \frac{1}{\omega}\left(\frac{\alpha}{1-\alpha}\frac{\omega}{\omega+\beta(1-\omega)} + 1 - \omega\right). \tag{32}$$

Comparing (31) and (32) shows that - when the optimal monetary policy is interior - central banks adopt a more contractionary monetary stance and tolerate less inflation if capital is mobile. The insights derived in Section 4.2 thus extend to tradable-biased negative supply shocks.

Gains from cooperation and international spillovers. Exactly for the same reasons described in Section 5, the optimal cooperative policy corresponds to the monetary stance that national central banks would choose under financial autarky. Lack of cooperation may thus lead to an overly tight monetary response to a global supply disruption. Efforts to contain domestic inflation through monetary tightenings, indeed, exacerbate the global scarcity of traded goods and impose negative externalities toward the rest of the world.

[37] To see this point, consider that if productivity is equal to its steady state value ($\xi = 1$), then the central bank can attain both full employment and zero inflation. It follows that if $\xi < 1$ it is optimal for the central bank to let inflation rise above its steady state value. Moreover, if the drop in ξ is sufficiently large, then $P_{i,0}^{fe} > \bar{P}_{i,0}$ and the optimal monetary policy entails a drop in employment below $\bar{L}$.

Supply disruptions biased toward the tradable sector thus have effects very similar to shocks boosting the global demand for tradable goods. What makes the two shocks similar is that they both lead to a global scarcity of tradable goods. It is then not surprising that some of the issues highlighted by this paper - such as monetary coordination problems arising from competitive appreciations - were present in the economic debate of the 1970s/1980s (Bruno and Sachs, 1985), a period characterized by negative supply shocks affecting the tradable sector.

7 Conclusion

To conclude, let us bridge the insights of this paper to the current macroeconomic situation. Of course, our model focuses on a specific aspect of the recovery from the Covid-19 recession, and so cannot do justice to the complex reality that policymakers have to face. We do believe, however, that a salient feature of the ongoing recovery is an excess global demand for tradable goods, relative to its supply. In this respect, our paper suggests that policies that increase the supply of tradable goods generate positive international spillovers. International cooperation, by helping national governments to internalize these spillovers, may thus play a role in ensuring a smooth recovery.

Appendix

A Proofs and additional derivations

A.1 Proof of Proposition 1

Substituting the constraints in the objective function reduces the central bank's problem to

$$\max_{P_{i,0}} \frac{1}{\omega_{i,0}} \left(\frac{\alpha}{1-\alpha} + 1 - \omega_{i,0} \right) \log P_{i,0} - \chi \left(P_{i,0} \right) + t.i.p., \tag{A.1}$$

where t.i.p. collects all the terms not affected by monetary policy, subject to

$$P_{i,0} \leq \left(\frac{\omega_{i,0}}{\omega} \frac{1 - \omega(1-\alpha)}{1 - \omega_{i,0}(1-\alpha)} \right)^{\omega_{i,0}(1-\alpha)} \equiv P_{i,0}^{fe}, \tag{A.2}$$

where we have also used $\bar{Y}^T = \omega \bar{L}$, and intuitively $P_{i,0}^{fe}$ denotes the level of inflation consistent with full employment $L_{i,0} = \bar{L}$.

We start by proving that the solution features $P_{i,0} > 1$. Imagine that the central bank sets $P_{i,0} \leq 1$. Then, since $\omega_{i,0} > \omega$, constraint (A.2) is slack. Moreover, recall that $\chi' \left(P_{i,0} \right) < 0$ for $P_{i,0} < 1$ and $\chi' \left(1 \right) = 0$, implying that the objective function is strictly increasing in $P_{i,0}$ when $P_{i,0} \leq 1$. This implies that it is optimal to set $P_{i,0} > 1$.

Now notice that, since $\chi' \left(P_{i,0} \right) > 0$ and $\chi'' \left(P_{i,0} \right) > 0$ for $P_{i,0} > 1$, the objective function reaches its maximum at $P_{i,0} = \bar{P}_0$, defined by

$$\chi' \left(\bar{P}_{i,0} \right) \bar{P}_{i,0} = \frac{1}{\omega_{i,0}} \left(\frac{\alpha}{1-\alpha} + 1 - \omega_{i,0} \right). \tag{A.3}$$

Then if

$$\chi' \left(P_{i,0}^{fe} \right) P_{i,0}^{fe} \leq \frac{1}{\omega_{i,0}} \left(\frac{\alpha}{1-\alpha} + 1 - \omega_{i,0} \right), \tag{A.4}$$

it is optimal to set $P_{i,0} = P_{i,0}^{fe}$, i.e. and maintain the economy at full employment $L_{i,0} = \bar{L}$. Otherwise it is optimal to set $P_{i,0} = \bar{P}_{i,0} < P_{i,0}^{fe}$, which implies that $L_{i,0} < \bar{L}$.

A.2 Proof of Lemma 1

To derive the consumption function, start by considering that from period $t = 1$ on the economy enters a steady state in which $R = 1/\beta$ and in every country consumption and output of both goods are constant. Let us denote by C_i^T and Y_i^T the consumption and output of tradable good in the final steady state in country i. Now iterate forward (11) and use the transversality condition to obtain

$$C_{i,0}^T + \frac{1}{R_0} \frac{C_i^T}{1-\beta} = Y_{i,0}^T + \frac{1}{R_0} \frac{Y_i^T}{1-\beta}, \tag{A.5}$$

where we have also used the fact that each country starts with zero assets. Now using the fact that

$$C_i^T = \beta R_0 C_{i,0}^T \frac{\omega}{\omega_{i,0}} \tag{A.6}$$

and rearranging the expression above gives

$$C_{i,0}^T = \frac{\omega_{i,0}(1-\beta)}{\omega_{i,0}(1-\beta+\omega\beta} \left(Y_{i,0}^T + \frac{1}{R_0}\frac{Y_i^T}{1-\beta} \right). \tag{A.7}$$

Since in the final steady state each country operates at full employment and both sectors have a linear production function, it is easy to check that

$$C_i^N = \frac{1-\omega}{\omega} C_i^T, \tag{A.8}$$

and

$$Y_i^T = \bar{L} - \frac{1-\omega}{\omega} C_i^T. \tag{A.9}$$

Combining this expression with (A.6), (A.7) and $\bar{Y}^T = \omega \bar{L}$ and rearranging gives expression (22).

A.3 Central bank's objective function under free capital mobility

Households' expected utility in country i is given by

$$\sum_{t=0}^{\infty} \beta^t \left(\omega_{i,t} \log \left(C_{i,t}^T \right) + (1-\omega_{i,t}) \log \left(C_{i,t}^N \right) - \chi \left(\frac{P_{i,t}}{P_{i,t-1}} \right) \right). \tag{A.10}$$

Now consider that starting from period 1 on the economy enters a steady state with $C_i^N = C_t^T(1-\omega)/\omega$ and $P_{i,t} = P_{i,t-1}$. Hence, households' lifetime utility can be written as

$$\omega_{i,0} \log C_{i,0}^T + (1-\omega_{i,0}) \log C_{i,0}^N - \chi(P_{i,0}) + \frac{\beta}{1-\beta} \log C_i^T + t.i.p, \tag{A.11}$$

where t.i.p. encapsulates all the terms not affected by monetary policy. Finally, using the expression above, $C_i^T = \beta R_0 C_{i,0}^T \omega/\omega_{i,0}$ and $C_{i,0}^N = Y_{i,0}^N$ gives the objective function (23).

A.4 Proof of Proposition 2

Substituting some constraints in the objective function reduces the central bank's problem to

$$\max_{P_{i,0}, C_{i,0}^T, Y_{i,0}^T} \frac{1}{1-\beta} \log C_{i,0}^T + \frac{1-\omega_{i,0}}{\omega_{i,0}} \log P_{i,0} - \chi(P_{i,0}) + t.i.p., \tag{A.12}$$

where t.i.p. collects all the terms not affected by monetary policy, subject to

$$C_{i,0}^T = \frac{\omega_{i,0}(1-\beta)}{\omega_{i,0}(1-\beta)+\beta} \left(Y_{i,0}^T + \frac{\bar{L}}{R_0(1-\beta)} \right). \tag{A.13}$$

$$P_{i,0}^{\frac{1}{\omega_{i,0}}} = \left(\frac{Y_{i,0}^T}{\bar{Y}^T}\right)^{\frac{1-\alpha}{\alpha}} \tag{A.14}$$

$$\alpha \left(Y_{i,0}^T\right)^{\frac{1}{\alpha}} \left(\bar{Y}^T\right)^{1-\frac{1}{\alpha}} + (1-\alpha)\bar{Y}^T + \frac{1-\omega_{i,0}}{\omega_{i,0}} C_{i,0}^T P_{i,0}^{\frac{1}{\omega_{i,0}}} \leq \bar{L}. \tag{A.15}$$

We start by proving that the solution features $P_{i,0} \geq 1$. Imagine that the central bank sets $P_{i,0} < 1$. Then, since $\omega_0 \geq \omega$ and $R_0 \geq 1/\beta$, constraint (A.2) is slack. Moreover, recall that $\chi'(P_{i,0}) < 0$ for $P_{i,0} < 1$ and $\chi'(1) = 0$, implying that the objective function is strictly increasing in $P_{i,0}$ when $P_{i,0} < 1$. This implies that it is optimal to set $P_{i,0} \geq 1$.

Notice that the left-hand side of constraint (A.15) is increasing in $P_{i,0}$, since both $Y_{i,0}^T$ and $C_{i,0}^T$ are increasing in $P_{i,0}$. Define by $P_{i,0}^{fe} \geq 1$ the unique value of $P_{i,0}$ that makes (A.15) hold as an equality. In the main text, $P_{i,0}^{fe}$ is implicitly defined by equation (25).

Now imagine that the solution is such that constraint (A.15) is slack. Then the optimal $P_{i,0}$ satisfies

$$\chi'(P_{i,0}) = \frac{1}{\omega_{i,0} P_{i,0}} \left(\frac{\alpha}{1-\alpha} \frac{\omega_{i,0}}{\omega_{i,0}(1-\beta)+\beta} \frac{Y_{i,0}^T}{C_{i,0}^T} + 1 - \omega_{i,0}\right). \tag{A.16}$$

Intuitively, at an interior optimum the marginal disutility from increasing inflation is equated to the marginal benefit in terms of higher output and consumption. Notice that both sides of equation (A.16) are increasing in $P_{i,0}$. However, we are focusing on scenarios in which all the solutions to (A.16), except the smallest one, violate constraint (A.15). Then defining by $\bar{P}_{i,0}$ the smallest solution to (A.16), the optimal monetary policy is such that $P_{i,0} = \min\left(P_{i,0}^{fe}, \bar{P}_{i,0}\right) \geq 1$.

A.5 Proof of Lemma 2

Since the reallocation shock is idiosyncratic $\omega_{i,0} > \omega$ and $R_0 = 1/\beta$. Now suppose that the trade balance is not in deficit, so that $C_{i,0}^T \leq Y_{i,0}^T$. Equation (22) then implies that $Y_{i,0}^T \geq \bar{Y}\omega_{i,0}/\omega$. But then constraint (18) is satisfied only if

$$\omega_{i,0}^{1-\alpha} \left(1 - \omega_{i,0}(1-\alpha)\right)^{\alpha} \leq \omega^{1-\alpha} \left(1 - \omega(1-\alpha)\right)^{\alpha}. \tag{A.17}$$

Notice that expression (A.17) holds as an equality if $\omega_{i,0} = \omega$, and the left-hand side of (A.17) is increasing in $\omega_{i,0}$. Then, since $\omega_{i,0} > \omega$, inequality (A.17) is violated. We have thus found a contradiction, implying that $C_{i,0}^T > Y_{i,0}^T$.

A.6 Proof of Proposition 3

These results can be derived following the same steps outlined in the proof to Proposition 1. The only difference is that with free capital mobility it is optimal to set $L_{i,0} = \bar{L}$ if

$$\chi'\left(P_0^{fe}\right) P_0^{fe} \leq \frac{1}{\omega_0} \left(\frac{\alpha}{1-\alpha} \frac{\omega_0}{\omega_0(1-\beta)+\beta} + 1 - \omega_0\right), \tag{A.18}$$

otherwise $L_{i,0} < \bar{L}$.

Moreover, it is easy to see that P_0^{fe} is not affected by capital mobility. This implies that if condition (A.18) is satisfied then the allocation under free capital mobility coincides with the one under financial autarky. Instead, $\bar{P}_0$ is lower under free capital mobility compared to financial autarky. This implies that whenever condition (A.18) is violated, the allocation under free capital mobility features less inflation and less employment than the one under financial autarky.

B Production with capacity constraints

There is a continuum of mass one of competitive firms in each sector $j = T, NT$. Each firm needs to perform two tasks, say A and B, to produce. Let L_A^j and L_B^j the amount of labor allocated respectively to tasks A and B by the representative firm in sector j. Final output Y^j is then[38]

$$Y^j = \left(\frac{L_A^j}{\alpha}\right)^{\alpha} \left(\frac{L_B^j}{1-\alpha}\right)^{1-\alpha}, \tag{B.1}$$

where $0 < \alpha < 1$ is a parameter determining the importance of the two tasks in the production process. Since labor is homogeneous, every worker is payed the same wage regardless of the task she fulfills.

Firms face a technological constraint, which limits the amount of labor that can be allocated to task B

$$L_B^j \leq (1-\alpha)\bar{Y}^j, \tag{B.2}$$

where the parameter $\bar{Y}^j > 0$ determines the severity of the capacity constraint. Notice that this constraint applies to period 0 only, and so should be understood as a short-run capacity constraint.

Denote by $L^j = L_A^j + L_B^j$ the total amount of labor employed in sector j. Now suppose that the capacity constraint does not bind in sector j. Since every worker is payed the same wage, the optimal allocation of labor by firms between the two tasks implies $L_A^j = \alpha L^j$, $L_B^j = (1-\alpha)L^j$ and $Y^j = L^j$. One can then see that the capacity constraint does not bind if $Y^j \leq \bar{Y}^j$. If this condition is violated, instead, $L_B^j = (1-\alpha)\bar{Y}^j$ and

$$Y^j = \left(\frac{L_A^j}{\alpha}\right)^{\alpha} \left(\bar{Y}^j\right)^{1-\alpha} = \left(\frac{L_{i,0}^j - (1-\alpha)\bar{Y}^j}{\alpha\bar{Y}^j}\right)^{\alpha} \bar{Y}^j, \tag{B.3}$$

where the second equality makes use of $L_A^j = L^j - (1-\alpha)\bar{Y}^j$.

The sectoral production functions thus take the form

$$Y^j = \begin{cases} L^j & \text{if } Y^j \leq \bar{Y}^j \\ \left(\frac{L^j-(1-\alpha)\bar{Y}^j}{\alpha\bar{Y}^j}\right)^{\alpha} \bar{Y}^j & \text{if } Y^j > \bar{Y}^j. \end{cases} \tag{B.4}$$

Output is thus linear in labor up to the threshold $\bar{Y}^j$. Once output exceeds $\bar{Y}^j$, labor productivity

[38] To simplify notation, in this appendix we omit the country and time subscripts.

declines in the quantity produced. The implication is that sectoral Phillips curves are non-linear

$$P^j = \begin{cases} W & \text{if } Y^j \leq \bar{Y}^j \\ \left(\frac{Y^j}{\bar{Y}^j}\right)^{\frac{1-\alpha}{\alpha}} W & \text{if } Y^j > \bar{Y}^j. \end{cases} \tag{B.5}$$

Intuitively, due to perfect competition sectoral prices are equal to sectoral marginal costs. When capacity constraints do not bind, marginal costs are constant and prices fully inherit the nominal wage rigidity. When capacity constraints bind, marginal costs - and so prices - become increasing in the quantity produced. Hence, sectoral Phillips curves have a flat part corresponding to levels of output below $\bar{Y}^j$, and become upward-sloped thereafter. Sectoral supply curves are therefore convex, as documented empirically by Boehm and Pandalai-Nayar (2022).

In the main text we focus on scenarios in which $Y^T_{i,0} \geq \bar{Y}^T$ and $Y^N_{i,0} \leq \bar{Y}^N$, so that capacity constraints bind in the tradable sector, but not in the non-tradable one. Given that in our experiments production in the tradable sector expands - while production in the non-tradable sector contracts - compared to their steady state values, a sufficient condition for this to be the case is to assume $\bar{Y}^T = \omega \bar{L}$ and $\bar{Y}^N = (1-\omega)\bar{L}$.

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