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The price of division: sticky prices and monetary policy in a fragmenting world

We develop a new model to analyze trade fragmentation scenarios, simulating an increase in trade restrictions between a Western bloc and an Eastern bloc of countries while leaving trade restrictions unchanged vis-à-vis a neutral bloc. We find that trade fragmentation lowers GDP and raises inflation in both East and West while the neutral bloc benefits from trade diversion. The Eastern bloc is hit harder than the Western bloc because it depends more on international trade.

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A new model for fragmentation analysis

Our model combines features of the macroeconomic literature (like nominal rigidities and dynamic adjustment) and trade literature (like endogenous firm entry and trade costs) to analyze trade fragmentation scenarios.

Trade fragmentation lowers GDP

Trade fragmentation lowers the efficiency of global production and, as a consequence, reduces the GDP of all involved countries. Neutral countries can benefit somewhat from trade diversion.

Trade fragmentation raises inflation

Trade fragmentation raises the cost of imported foreign goods, thereby driving up domestic inflation. If this inflation feeds into higher wages, it can be very persistent.

Abstract[1]

We develop a dynamic three-region model combining features of modern trade models and macroeconomic models to study the role of nominal rigidities and monetary policy after trade fragmentation shocks. We find that trade fragmentation substantially reduces GDP and persistently raises inflation. Nominal rigidities play an important role in shaping the adjustment process. Monetary policy faces a trade-off between stabilizing inflation and output, but reacting to the surge in inflation with a lag ("looking through") can reduce the economic downturn at relatively low cost in terms of inflation.

1 Introduction

Geopolitical tensions are on the rise and with them the fear that the global trading system might be fracturing into blocs that trade primarily internally. This has motivated the International Relations Committee (IRC) of the Eurosystem to provide a detailed report analyzing the implications of trade fragmentation from a central bank's perspective (Attinasi et al., 2024). We analyze the dynamic adjustment to such a fracturing in a dynamic general equilibrium model with nominal rigidities and find that trade fragmentation permanently lowers GDP and persistently raises inflation. We also study the role of nominal rigidities and monetary policy during the adjustment process.

The economic effects of geopolitical fragmentation have received quite a bit of attention recently. However, most analyses of this topic use static models, which are neither able to track the adjustment process, nor to take account of nominal rigidities and monetary policy. In this paper, we develop a dynamic general equilibrium model of three countries/blocs that combines important features of both international trade and macroeconomic models.

On the trade side, our model includes endogenous firm entry, firm heterogeneity and selection into export markets (only the most productive firms take up export). These features are standard in trade models since Melitz (2003), because they have been shown to be empirically important. On the macro side, our model includes intertemporally maximizing households, physical capital, investment adjustment costs and nominal rigidities. The latter are important because they are a prerequisite for monetary policy to have real effects.

We calibrate our model to broadly capture three blocs of the global trading system: one bloc centered around the USA and Europe, one bloc centered around China and Russia, and a third, neutral bloc. This approach follows the setup in the recent IRC report (Attinasi et al., 2024), which uses primarily voting behavior at the UN to define geopolitical alignment. We use this segmentation to calibrate the size of the three blocs in the model as well as the trade flows between these blocs (pre-fragmentation).

We then model trade fragmentation as an increase in trade costs between the Western bloc and the Eastern bloc that affects trade in both directions, while trade costs between either of the two and the neutral bloc remain unchanged. We find that trade fragmentation does long-lasting, in fact permanent, damage to the economies involved. Both GDP and investment in physical capital are permanently lowered because

[1] The paper was previously circulated under the title "Trade fragmentation and nominal rigidities. For more accessible information on the visual content of this article, please contact the authors directly: wolfgang.lechthaler@oenb.at and mariya.mileva@csulb.edu.

the availability of cheap, foreign products is reduced. Due to love of variety, this is directly detrimental to domestic welfare, and it also implies that relatively more of total production is undertaken by firms with relatively low productivity, and less by highly efficient exporters.

Trade fragmentation also raises the price of imported goods, thereby pushing up inflation. Depending on the exact specification of price rigidity (local vs. producer currency pricing), and wage rigidity, trade fragmentation leads to persistently higher inflation of domestically produced goods. Ultimately, inflation goes back to the target of the central bank, but this may take a very long time. We also discuss the role of nominal rigidities in detail and find that local currency pricing makes the inflation of imported goods very persistent, while nominal wage rigidity importantly contributes to second-round effects on domestic inflation. Finally, we discuss the role of monetary policy and find that a monetary policy that fights inflation more aggressively can succeed in curbing the rise in inflation, but only at the cost of a deeper downturn in the short run. If the central bank delays its reaction to the price shock, this can reduce the drop in GDP growth at the cost of a relatively small increase in inflation.

This paper contributes to the aforementioned trade fragmentation report of the IRC (Attinasi et al., 2024). This report provides a comprehensive analysis of trade fragmentation from a central bank's perspective. The report combines insights from both empirical analyses and model-based simulations. Among other things, it finds that decoupling between specific trading partners is already happening, and decoupling is associated with substantial losses in GDP for all involved countries. The numerical simulations in the report are primarily based on the model by Baqaee and Farhi (2024). We complement this analysis by providing a dynamic perspective, focusing on the role of nominal rigidities and monetary policy.

Our study also contributes to the expanding literature on the economic costs of geoeconomic fragmentation (see Attinasi et al., 2023; Bolhuis et al., 2023; Cerdeiro et al., 2021; Javorcik et al., 2024; Aiyar et al., 2023; Góes and Bekkers, 2022; Hakobyan et al. (2023) among others). This body of work typically quantifies the long-term costs of fragmentation by simulating scenarios with sharply increased barriers to trade, foreign direct investment, or technology diffusion between blocs. Most analyses in this literature are conducted in static frameworks that abstract from the transitional dynamics and the role of macroeconomic frictions, areas where our focus lies.

Our paper is also related to the recent literature that examines the macroeconomic effects of protectionism and higher trade costs, both empirically and theoretically (see, for example, Auray et al., 2019; Barattieri et al., 2021; Barbiero et al., 2019; Erceg et al., 2018; Larch and Lechthaler, 2016; Lechthaler, 2016; Lindé and Pescatori, 2019; Lechthaler and Mileva, 2021). However, most of these works do not explore the role of nominal frictions and monetary policy. A closely related strand of literature includes open economy New Keynesian models that explore the interactions of trade policy with monetary policy. Recent works in this area include Cacciatore and Ghironi (2021), Lechthaler and Mileva (2024), Monacelli (2025), Bergin and Corsetti (2023), Bianchi and Coulibaly (2025), and Bergin and Corsetti (2025). While these papers adopt a small open economy or a two-country framework, our three-region setup captures trade diversion effects. A closely related study is Kalemli-Özcan et al. (2025), which features a multi-country model with nominal frictions but omits firm dynamics and export market selection - key channels for trade policy transmission.

2 Model and calibration

In this section, we provide a short non-formal description of the main ingredients of the model as well as the calibration approach. For more details, the interested reader is referred to the appendix.

We use a dynamic general equilibrium model that consists of three countries/blocs, neutral (N), West (W) and East (E), which trade with each other. Each country produces a final good and sells it to domestic and foreign consumers and capital investors. The model features a two-tier production structure, which allows us to combine important features of international trade and macroeconomic models.

In the first stage, heterogeneous firms produce a continuum of intermediate goods. The number of goods in this stage is endogenous: setting up a firm to produce a new good requires a sunk entry cost, and every period an exogenous fraction of firms is destroyed. Because the number of goods is endogenous, it will react to changes in the economic environment, like business cycle shocks or trade barriers. The firms in this sector sell their goods under monopolistic competition to domestic retailers, who represent the second stage of production. The retailers produce the final good using a CES aggregation function and sell it to domestic and foreign consumers and capital investors, again under monopolistic competition.

The bundle of goods to serve the domestic market is different from the bundle of goods to be sold abroad because firms producing export goods have to pay a fixed export cost. This gives rise to selection into export markets as in Melitz (2003) and Ghironi and Melitz (2005). Fixed costs and selection into export markets are specific to the destination, which means that the bundle of varieties sold abroad differs for each importing country.

Firms in the retail sector face quadratic price adjustment costs, i.e., it is costly for them to change the price. This is a common way to introduce nominal rigidities in dynamic macroeconomic models: because price adjustment is costly, firms only slowly adjust their prices in response to economic shocks. This implies a meaningful distinction between nominal and real variables, and inflation is well defined. Similarly, we introduce nominal wage rigidity by assuming that workers produce a slightly differentiated labor input and sell it under monopolistic competition facing quadratic wage adjustment costs. An important implication of the presence of nominal rigidities is that monetary policy does not only affect nominal variables, but also real variables (in the short run). We assume that monetary policy is implemented through a standard Taylor rule, which responds to inflation and output fluctuations.

We calibrate the parameters in the model so that it can match important statistics in the data. A detailed description of the calibration can also be found in the appendix. Here we only want to point out that one period in the model simulation is to be interpreted as one quarter, and that we follow Attinasi et al. (2024) in assigning specific countries to each of the three blocs. We then use data on GDP and international trade to calibrate the size of the blocs and their trade linkages.

3 Results

3.1 Baseline results

In this section we describe the effects of an increase in trade costs between the Western bloc (W) and the Eastern bloc (E). Both trade costs for imports from E to W and for imports from W to E are raised by

60 percentage points.[2] In contrast, the trade costs for trade associated with the neutral bloc (N) remain unchanged. For our baseline simulations we assume that internationally, trade goods are invoiced in the importer's currency and that nominal wages are sticky, too. In the following section we will discuss the implications of these assumptions in more detail.

Chart 1 illustrates the implications for international trade. As expected, the increase in trade costs substantially reduces global trade, defined as the sum of all imports and exports between the three blocs.[3] This reduction is driven by the sharp drop in trade between West and East. For all the blocs, exports and imports decrease in similar magnitudes so that the trade balance (depicted relative to GDP) does not move by much. East's exports are reduced substantially more than West's exports, because it is the smaller bloc and thus more reliant on trade with the other. The dynamic structure of our model allows for gradual adjustment in trade flows, so that the longer-run effects are substantially stronger than the short-run effects. The new, lower level of trade is reached in about 20 quarters, i.e. five years.

In contrast to the trade of East and West, the imports and exports of the neutral bloc increase.[4] As is common in gravity models, the trade of two countries/blocs depends not only on the direct trading costs but also on the trading costs between their trading partners. Since East and West trade less with each other, trade with the neutral bloc becomes more attractive. This is the well-known trade diversion effect, but it is rather minor, especially when compared to the substantial losses in trade between East and West.

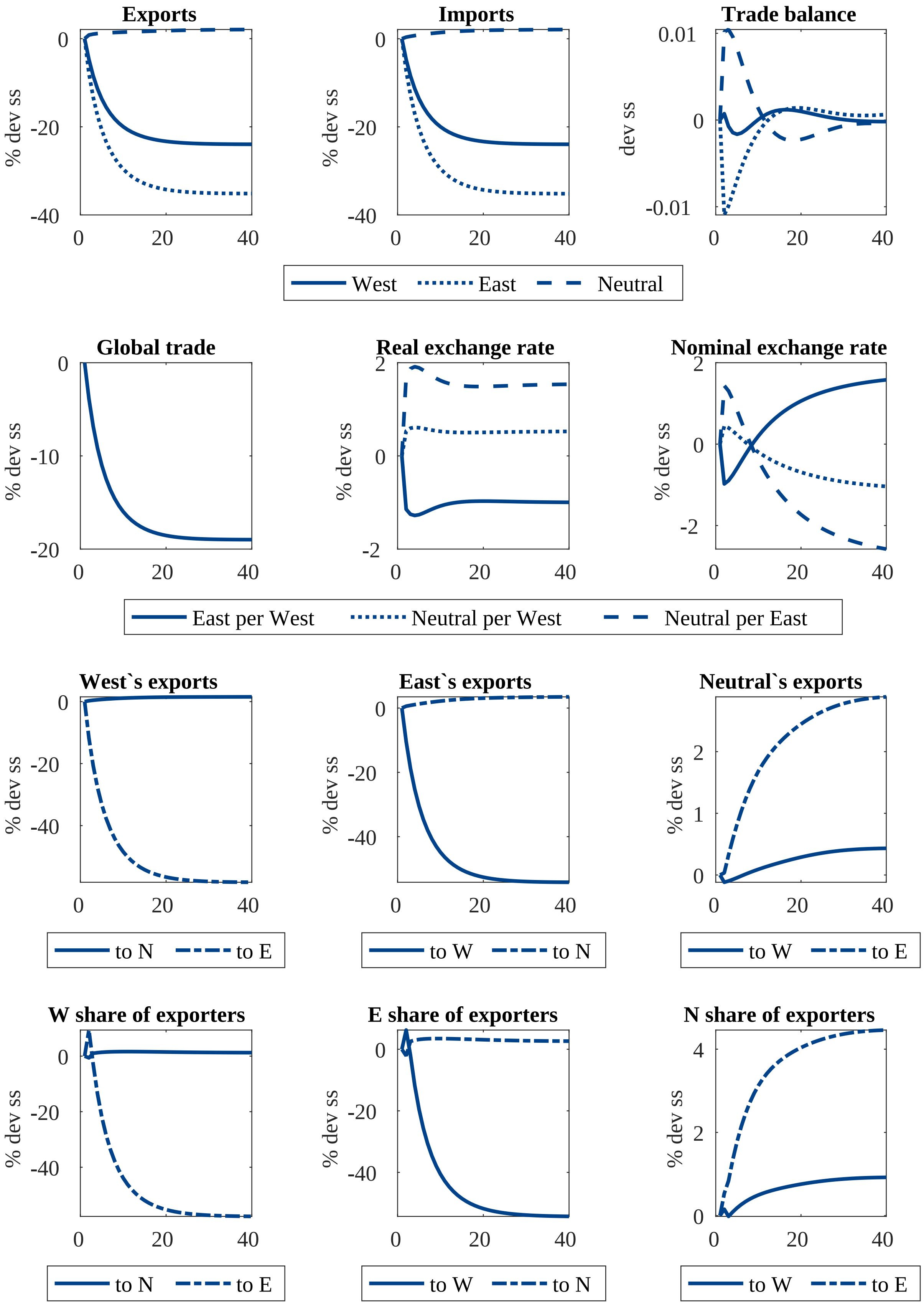
Chart 1 also illustrates the development of exchange rates. The main variable of interest is the real exchange rate because it is the international relative real price that governs international trade. The chart shows the three bilateral exchange rates, e.g., dashed lines show the relative price of the West's goods in terms of the neutral bloc's goods. The West's real exchange rate is permanently appreciating vis-a-vis the neutral bloc because trade fragmentation leads to a permanently higher price level in the West (see discussion further below). The real depreciation of the neutral bloc supports its expansion of exports. Also note that the real depreciation of the neutral bloc against the East is much larger than the one against the West, explaining why its exports to the East grow much more than its exports to the West. The nominal exchange rate exhibits more volatile behavior, first appreciating (from the West's perspective) and then depreciating. Thus in the longer run, the nominal exchange rate counteracts to a certain extent the effects of inflation to support the exports of the West, but this effect on the real exchange rate is fairly limited as shown in the chart.

Chart 1 also illustrates the development of the share of exporting firms among all active firms. This is an important metric because in our model, exporters are larger and more efficient than the average firm (only for the most efficient firms it pays off to pay the fixed cost of exporting). In a sense, international trade allows a country access to highly efficient foreign firms. The flip side is that trade fragmentation reduces this access, lowering allocative efficiency, because a bigger share of total production comes from less efficient domestic firms that only serve the domestic market. The chart illustrates that this is exactly what happens. The trade barriers between East and West cause many exporters to exit the market. The improved opportunities of trade with the neutral bloc have the opposite effect on the share of exporters in N, but again this effect is small relative to the much stronger direct effect of trade barriers.

[2] This corresponds to the "mild decoupling" scenarios in the IRC report that targets a reversal of trade levels to the mid-1990s.
[3] So trade within the blocs is not taken account of.
[4] Neutral's exports to the East increase relatively more than those to the West, because the East is more dependent on trade.

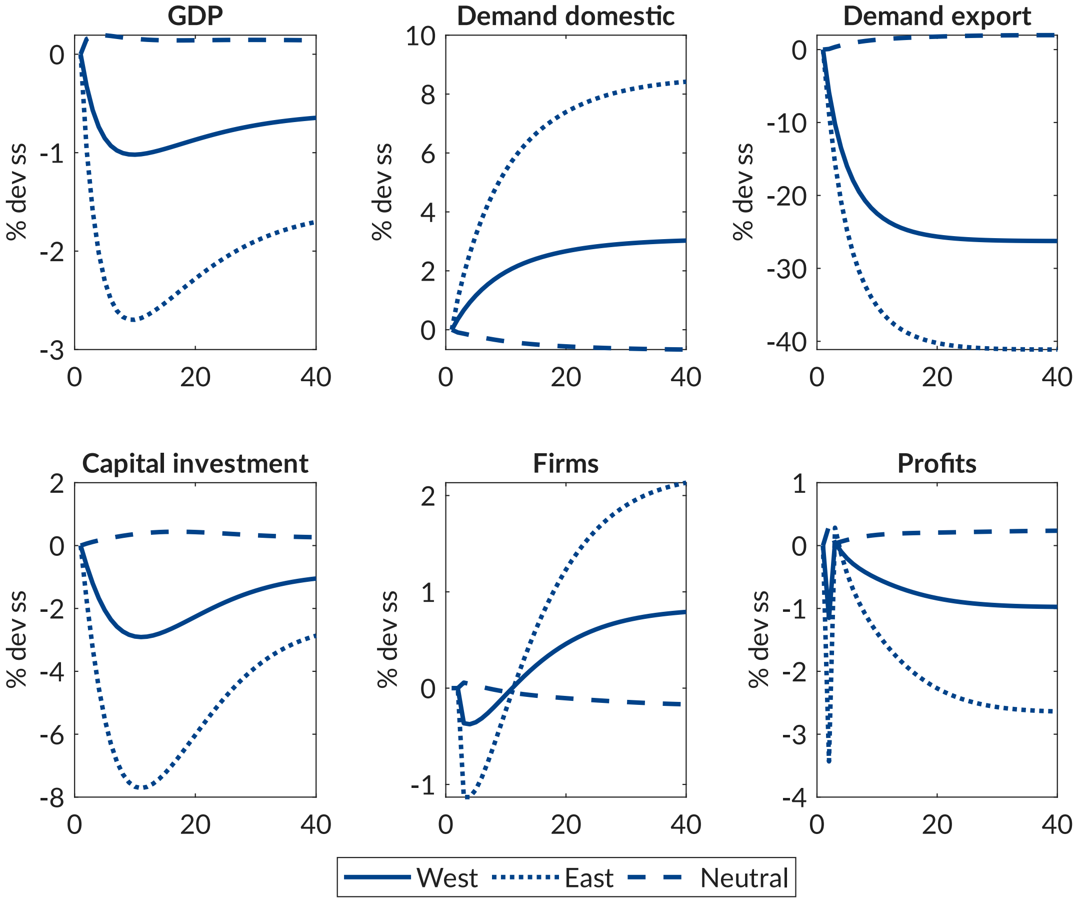
Chart 1

Effects of an increase in trade costs between West and East on international trade



Note: Quarters on the horizontal axis, percent (point) deviations from steady state on the vertical axis.
Source: Authors' calculations.

Chart 2
Effects of an increase in trade costs between West and East on economic activity



Note: Quarters on the horizontal axis, percent (point) deviations from steady state on the vertical axis.
Source: Authors' calculations.

Chart 2 illustrates the effects on real activity more generally. Most importantly, both East and West experience substantial declines in real GDP. In line with the results above, the decline in East's GDP is stronger, because it is more dependent on the West, but the effect is also substantial for the West. In contrast to international trade, however, the short-run effects are even stronger than the long-run effects, i.e., GDP is substantially undershooting its long-run equilibrium. This is mainly explained by the behavior of capital investment and firm investment, which both drop very quickly, but then recover.

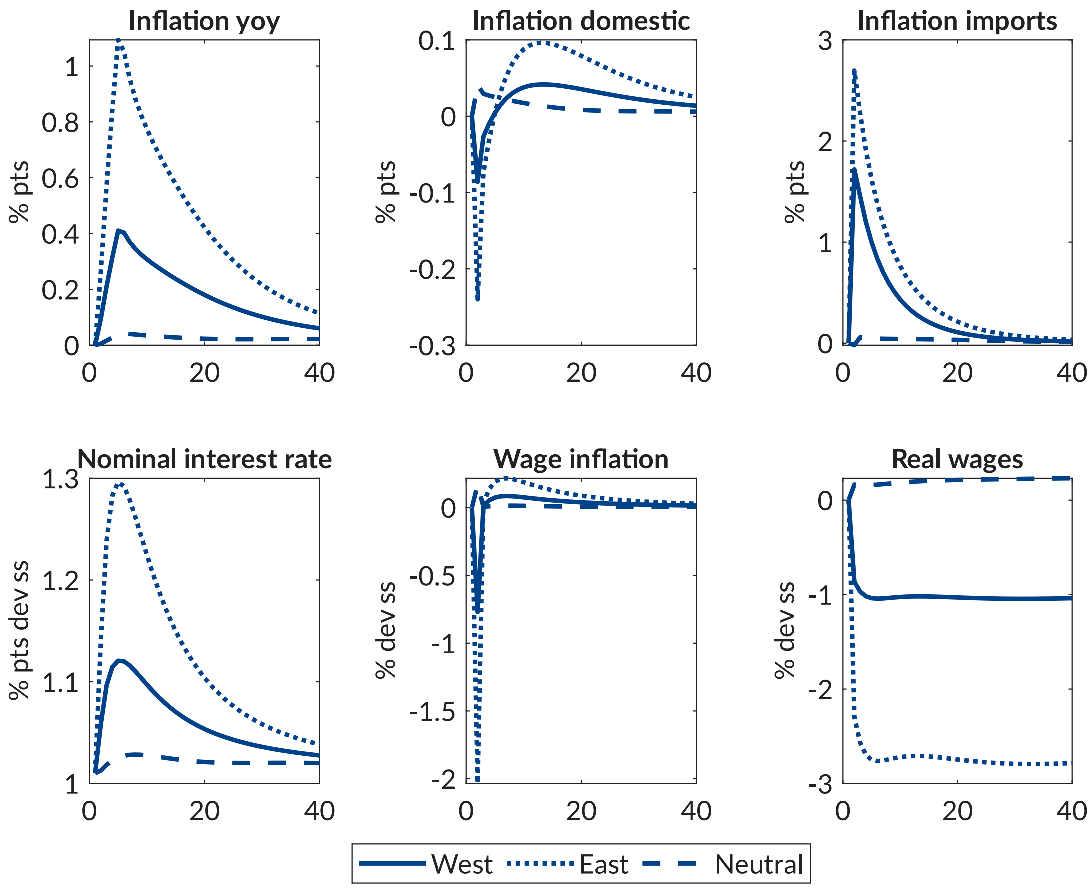
Reduced and more costly international trade makes firms less profitable[5] and investment in physical capital less attractive. In the new steady state, the stock of capital will be lower, reducing the level of investment needed to maintain it. Additionally, during the transition phase, the stock of capital has to be driven down so that capital investment substantially undershoots its new equilibrium level.

For firm entry, the picture is more nuanced. There, too, reduced profitability induces a strong drop in the short run. However, in the longer run, trade restrictions imply that less domestic demand can be satisfied by highly efficient foreign exporters and thus more has to be satisfied by (on average) less efficient domestic firms. This is a well known result in the Melitz model and still valid in our framework. In the long run, this

[5] The temporary increase in profits during the transition phase is explained by firm exit and low wages.

Chart 3

Effects of an increase in trade costs between West and East on nominal variables



Note: Quarters on the horizontal axis, percent (point) deviations from steady state on the vertical axis.
Source: Authors' calculations.

implies that the total number of firms is higher and thus firm entry has to be higher, too.[6]

Finally, chart 3 shows the effects of trade fragmentation on inflation and related variables. Inflation increases substantially, not only in the short run but in fact very persistently. Even after 20 quarters, the inflation rate is still far from target, despite a strong reaction in the nominal interest rate. The disaggregated charts show that the surge in inflation is primarily driven by more expensive imports. Higher trade costs make imported goods directly more expensive and reduce their availability, which also tends to increase their prices. Due to price adjustment costs in terms of domestic prices (local currency pricing), this increase is very persistent.[7]

In the very short run, the drop in the price of domestically produced and sold varieties dampens the effect of import price inflation, but very soon the increased demand for domestically produced goods also implies positive inflation for domestic varieties, reinforcing the effect of import inflation on overall inflation. The short-run drop in the inflation of domestically produced varieties is caused by a sharp drop in nominal wages on impact, which stems from the reduced demand for labor associated with the trade shock. In later stages, nominal wages keep track with overall inflation to keep real wages flat.

In line with earlier results, the effects are stronger for the Eastern bloc than for the Western bloc, but

[6] The higher number of firm entries, despite lower profits, can be sustained due to lower wages and thus lower entry costs.
[7] Further below, we will discuss the role of the invoicing assumption in more detail.

qualitatively similar. Inflation also rises in the neutral bloc, but in contrast to the West and the East, this is not driven by trade restrictions but rather by the increase in demand and economic activity associated with the small boom stemming from trade diversion. Consequently, the neutral bloc is the only one experiencing rising real wages.

3.2 The role of nominal rigidities

In this section we discuss the role of nominal rigidities for the effects of trade fragmentation. We start by analyzing the role of the currency of pricing.

For our benchmark simulations, we have assumed local currency pricing (LCP), i.e., imported goods are priced in the local currency and price adjustment costs accrue to prices in the local currency, i.e., the currency of the consumer. One alternative assumption is producer currency pricing (PCP), where imported goods are priced in the currency of the originating country, and price adjustment costs are incurred in that currency.

This assumption is especially important when it comes to changes in trade costs (and tariffs likewise). Under LCP, it is costly for the importer to pass on the increase in trading costs to their customers, because the adjustment costs accrue to the final consumer price. Therefore, the price adjustment is muted in the short run, and stretched out over time. Ultimately, consumers still have to pay a higher price, but the price increase is more gradual.

This is different under PCP because the price adjustment cost is incurred in the producer's currency, and the trade costs come on top of that, so it is ”free” for the importer to adjust the price for the consumer. Consequently, the adjustment is much stronger, more immediate and less gradual.

This can be very well seen in chart 4, illustrating selected variables for the Western bloc and the same trade shock as before, comparing the development under the assumption of PCP and LCP. The most striking difference is in terms of import price inflation, which spikes much more sharply in the short run, but is then much less persistent. Headline inflation also spikes on impact of the shock, then drops as import price inflation decreases; however, headline inflation stays persistently elevated after that due to the effect on the prices of domestically produced varieties. In fact, in the short to medium run, the inflation of domestically produced goods is higher under PCP, partially counteracting the effect of lower import price inflation, so that inflation is similar in both cases in the medium run. Thus, inflation is more volatile under PCP but still very persistent due to the effect of trade fragmentation on domestic prices. The short-run drop in real GDP is also slightly stronger under PCP.

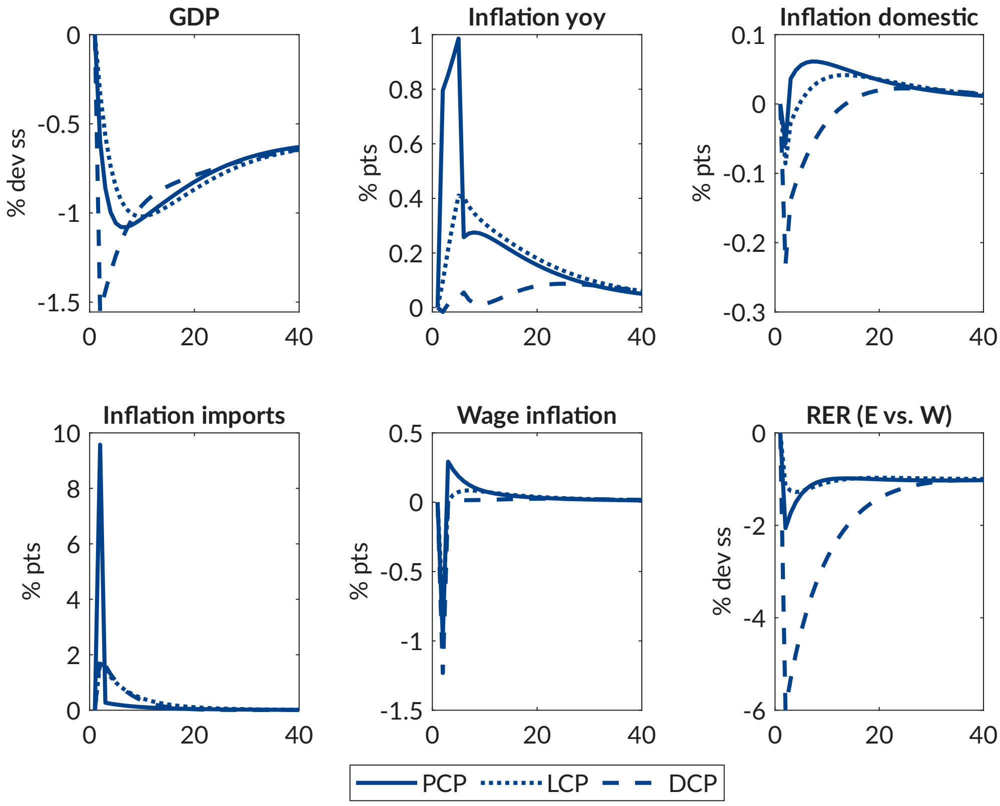
Another alternative assumption to LCP is dominant currency pricing, DCP (see, e.g., Gopinath et al., 2020. It is based on the observation that the US dollar plays a dominant role as invoicing currency in much of international trade. Although in a fracturing world economy, the dominance of the US dollar is very likely to diminish, it is still worthwhile to explore the implications of DCP. To do so, we assume that trade that involves the Western bloc is invoiced in the currency of the Western bloc.[8]

The results are shown by the dashed line in chart 4. As to be expected, the effects of trade fragmentation on import inflation are very similar to those under LCP because in both cases, imports are invoiced in the

[8] Trade between the Eastern bloc and the neutral bloc is still assumed to be subject to LCP, because the two blocs would no longer use the US dollar for their trade in a fractured world economy.

Chart 4

Effects of an increase in trade costs between West and East on the Western bloc, producer currency pricing vs. local currency pricing vs. dominant currency pricing



Note: Quarters on the horizontal axis, percent (point) deviations from steady state on the vertical axis.
Source: Authors' calculations.

currency of the Western bloc. However, in the short run, the drop in GDP is much stronger under DCP. That is the case because under US dollar pricing, the pass-through of increased trade costs to import prices in the Eastern bloc is much faster. As a consequence, the drop in exports to the Eastern bloc happens much faster, with detrimental effects for GDP.

The drop in GDP and aggregate demand in the Western bloc feeds into lower wages, which in turn feeds into lower inflation of domestically produced goods. This disinflationary effect is now so strong that the increase in headline inflation is much smaller.[9] Thus, DCP implies that trade fragmentation has only negligible effects on overall inflation, but at the cost of a much stronger downturn in economic activity.

That the strong persistence in the inflation of domestic prices is importantly driven by wage rigidity is demonstrated by chart 5, for which it is assumed that prices are determined under LCP, while wages are fully flexible. In this case, the drop in wages on impact of the trade shock is larger, but the later catch-up of nominal wages is subdued.[10] Lower wage inflation lowers the inflation of domestic varieties to such an extent that it is negative for longer and only slightly positive in the medium run.[11] Consequently, overall inflation is much lower in this scenario. Thus, in our model, second-round effects of trade fragmentation

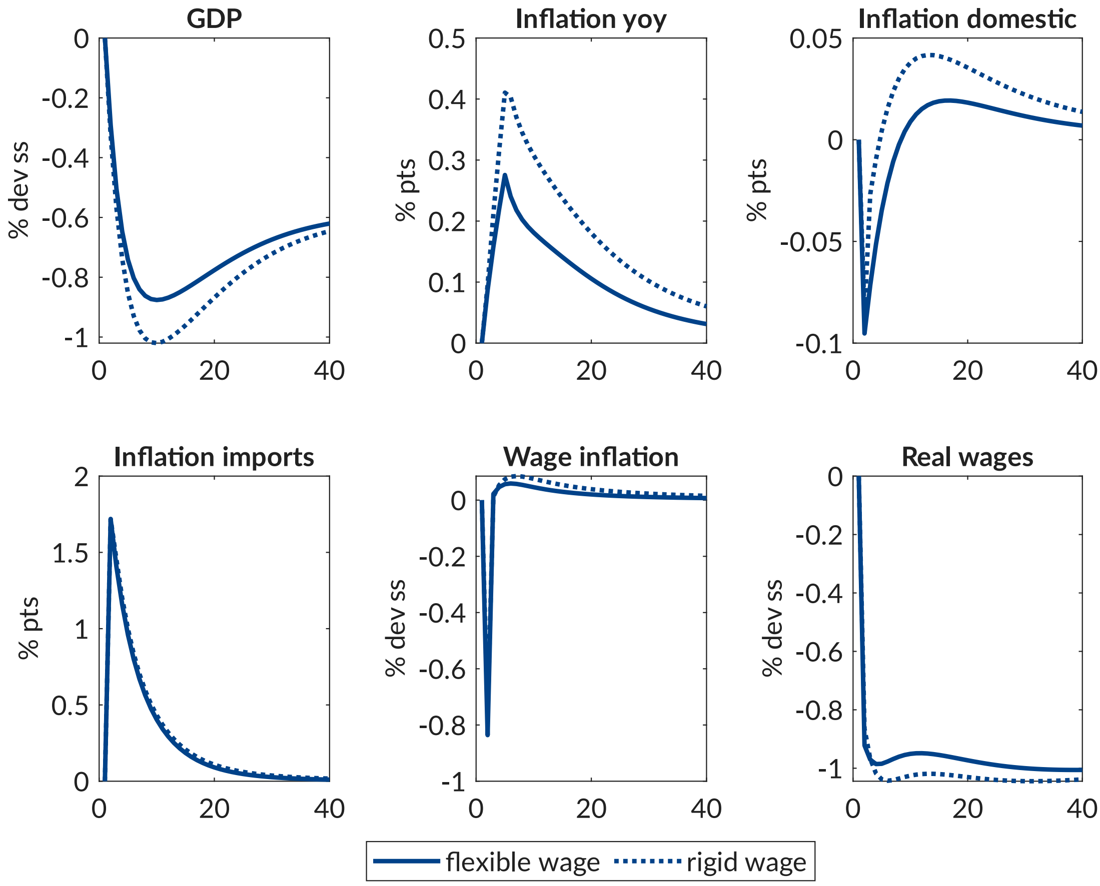
[9] The changed response in inflation also implies a much stronger depreciation in the real exchange rate of the West relative to the East.

[10] Note that the sharp drop in wage deflation on impact implies a scaling of the graph that makes the differences appear very small although they are quite substantial.

[11] For larger degrees of wage rigidity, the inflation of domestic varieties can stay negative throughout the transition.

Chart 5

Effects of an increase in trade costs between West and East on the Western bloc; flexible wages vs. rigid wages



Note: Quarters on the horizontal axis, percent (point) deviations from steady state on the vertical axis.
Source: Authors' calculations.

on domestic prices importantly hinge on wage rigidity. Wage rigidity also importantly contributes to the strong undershooting of real GDP.

Finally, chart 6 illustrates the effects of nominal rigidity by comparing the benchmark simulation with a model in which both prices and wages are fully flexible.[12] Because showing nominal variables in this case does not make much sense, we show different variables than above.

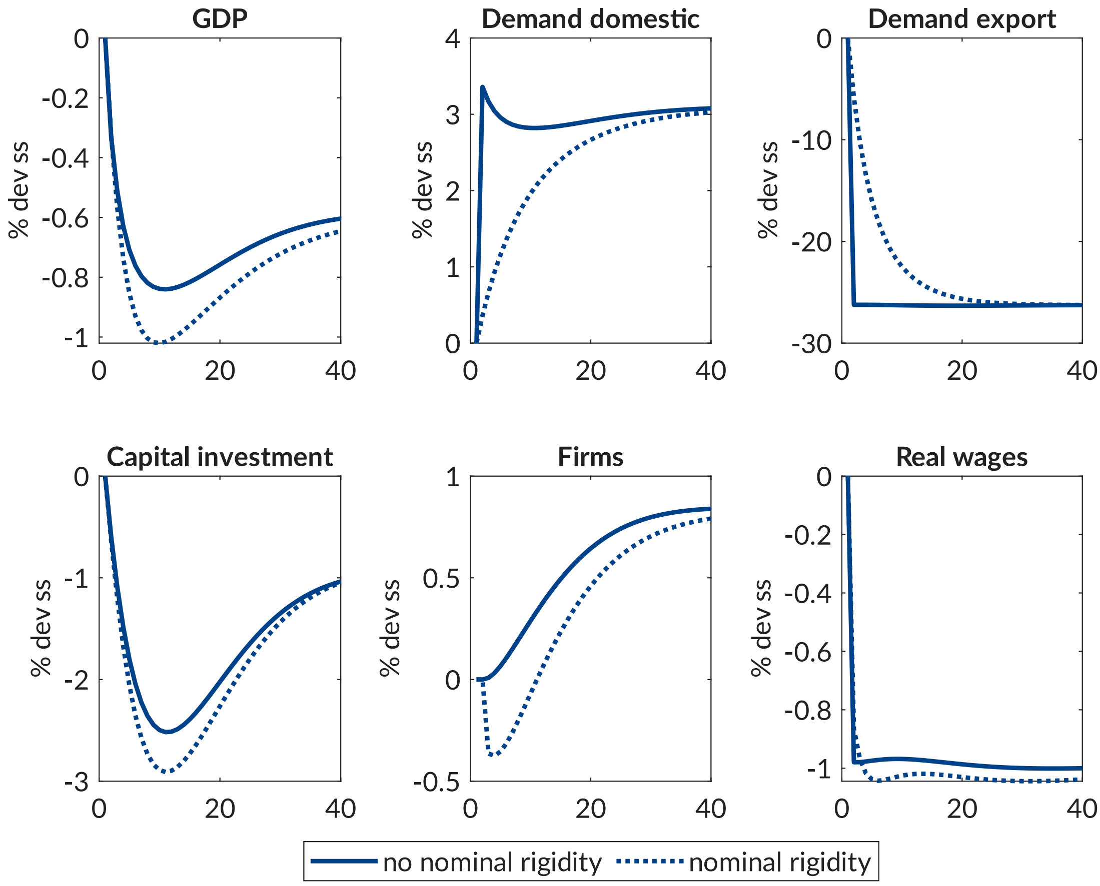
It can clearly be seen that the adjustment is much faster with flexible prices and wages, especially the shift from export demand to domestic demand. There is still a degree of undershooting in GDP, driven by capital investment, which undershoots its long-run value for the same reason as above: the capital stock is lower in the new equilibrium and thus in the transition phase, the capital stock has to be run down. However, the undershooting of firm entry is avoided in this case, so that the number of firms is constantly increasing toward its new equilibrium level.

Overall, we conclude that nominal rigidities, be it in the form of wage rigidity or price rigidity, matter a great deal for the adjustment to trade fragmentation, which provides a potential role for monetary policy to play in this adjustment process, a question that will be addressed in the following section.

[12] The case of PCP and flexible wages is shown in the appendix. In this case the surge in inflation is strong but short-lived, because both aspects causing persistent inflation, LCP and wage rigidity, are shut off. The appendix also shows the cases of reduced price adjustment costs and fully flexible prices.

Chart 6

Effects of an increase in trade costs between West and East on the Western bloc; the role of nominal rigidity



Note: Quarters on the horizontal axis, percent (point) deviations from steady state on the vertical axis.
Source: Authors' calculations.

3.3 Monetary policy

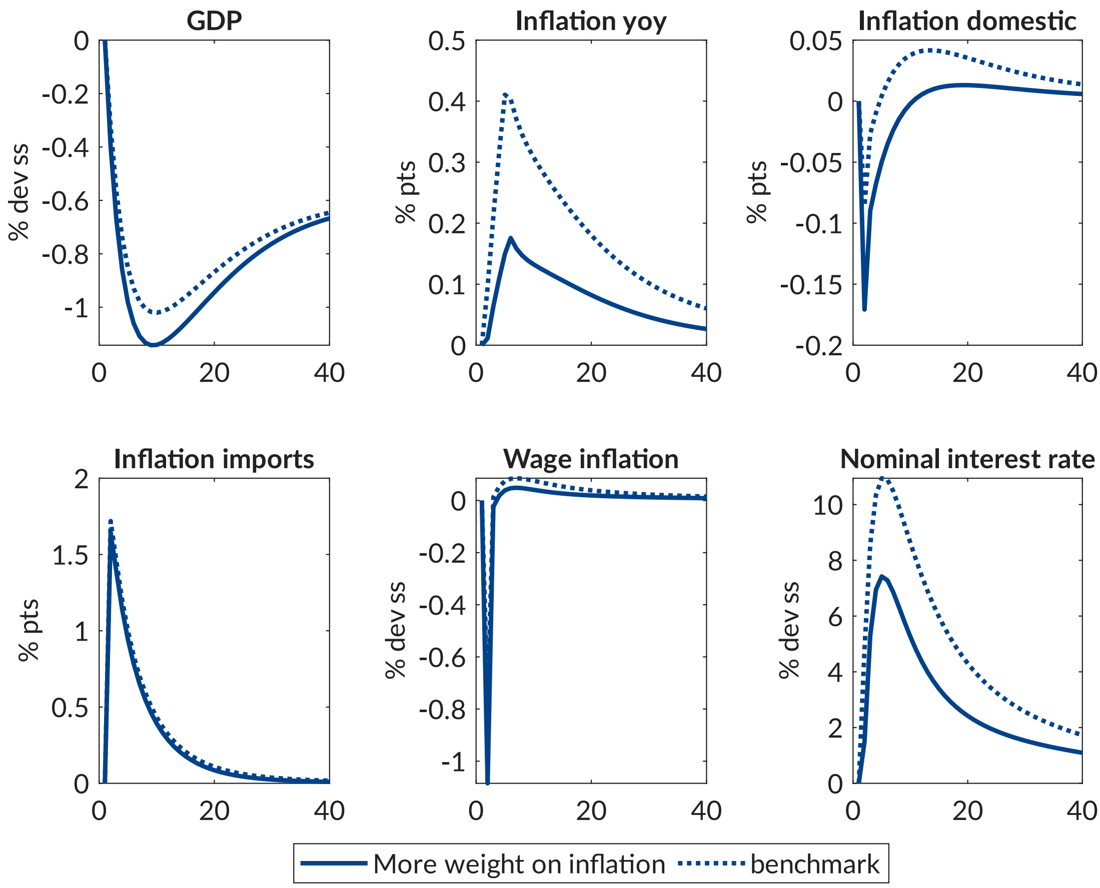
In this section, we discuss the role that monetary policy plays in the adjustment to trade fragmentation shocks. For chart 7, it is assumed that monetary policy is much more aggressive in response to deviations of inflation from target, i.e., it changes the interest rate level more in response to any given rise in inflation. Specifically, the weight on inflation in the Taylor rule is doubled from 1.7 to 3.4 in the Western bloc, while monetary policy in the other blocs stays unchanged. This is a rather extreme policy change, but serves to illustrate the role of inflation targeting.

It can be seen that the stronger reaction to inflation is successful in substantially limiting the surge in inflation in the Western bloc, but the increase in inflation is similarly persistent. As to be expected, more aggressive monetary policy acts primarily through reducing the inflation of domestically produced goods, while imported inflation is not changed by much. In fact, the strong reaction of the central bank induces a deflation in domestic prices that counteracts (but not fully offsets) the inflation in imported goods. Thus the central bank is successful in counteracting domestic second-round effects. However, this comes at the cost of lower real wages and a substantially reduced GDP in the short run.[13]

[13] It might seem surprising that the nominal interest rate is in fact rising less in the scenario where monetary policy is more ag-

Chart 7

Effects of an increase in trade costs on the Western bloc for different weights on inflation



Note: Quarters on the horizontal axis, percent (point) deviations from steady state on the vertical axis.
Source: Authors' calculations.

In chart 8, we illustrate the case of a central bank that puts more weight on the output gap (the coefficient is doubled from 0.12 to 0.24), which is the mirror image of the exercise above. As expected, this makes the economic downturn less severe, but it does so at the cost of higher inflation. Under the more lenient monetary policy, the short-run disinflation in domestic prices is almost avoided and domestic inflation substantially increased. Note that the additional inflation is quite large, whereas the gains in GDP are very modest.

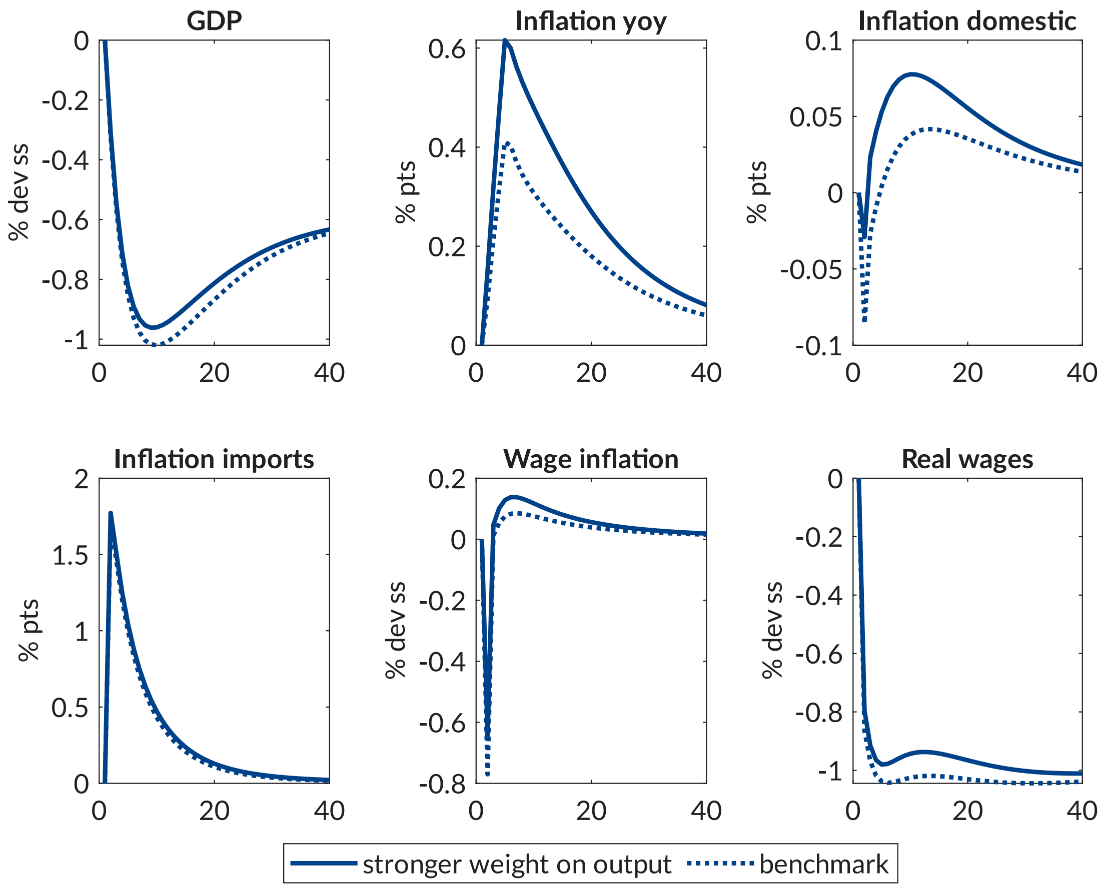
In a final experiment, we assume that monetary policy does not react at all for the first four quarters, i.e., it keeps the interest rates constant, before it "re-activates" its Taylor rule (with the benchmark coefficients). This experiment is motivated by the realization that this is a structural shock that works like a negative supply shock, and the central bank might want to "see through" the shock, but only to a certain extent.

Chart 9 illustrates the implications. Even though monetary policy is inactive for only a year, the development of GDP is more beneficial throughout the transition. This comes at the cost of higher inflation, but only in the short run, while in the medium run, inflation is almost identical, even slightly lower. Furthermore, compared to chart 8, the increase in inflation is more modest, even though the effect on GDP is larger. This is so because here, monetary policy is only temporarily more lenient, while in the other it is

gressive, but note that inflation is rising much less and thus a weaker reaction in the nominal interest rate is implied. Thus, a more aggressive policy stance lowers inflation volatility without the need of more volatile interest rates.

Chart 8

Effects of an increase in trade costs on the Western bloc for different weights on output



Note: Quarters on the horizontal axis, percent (point) deviations from steady state on the vertical axis.
Source: Authors' calculations.

permanently so (following a more lenient rule).

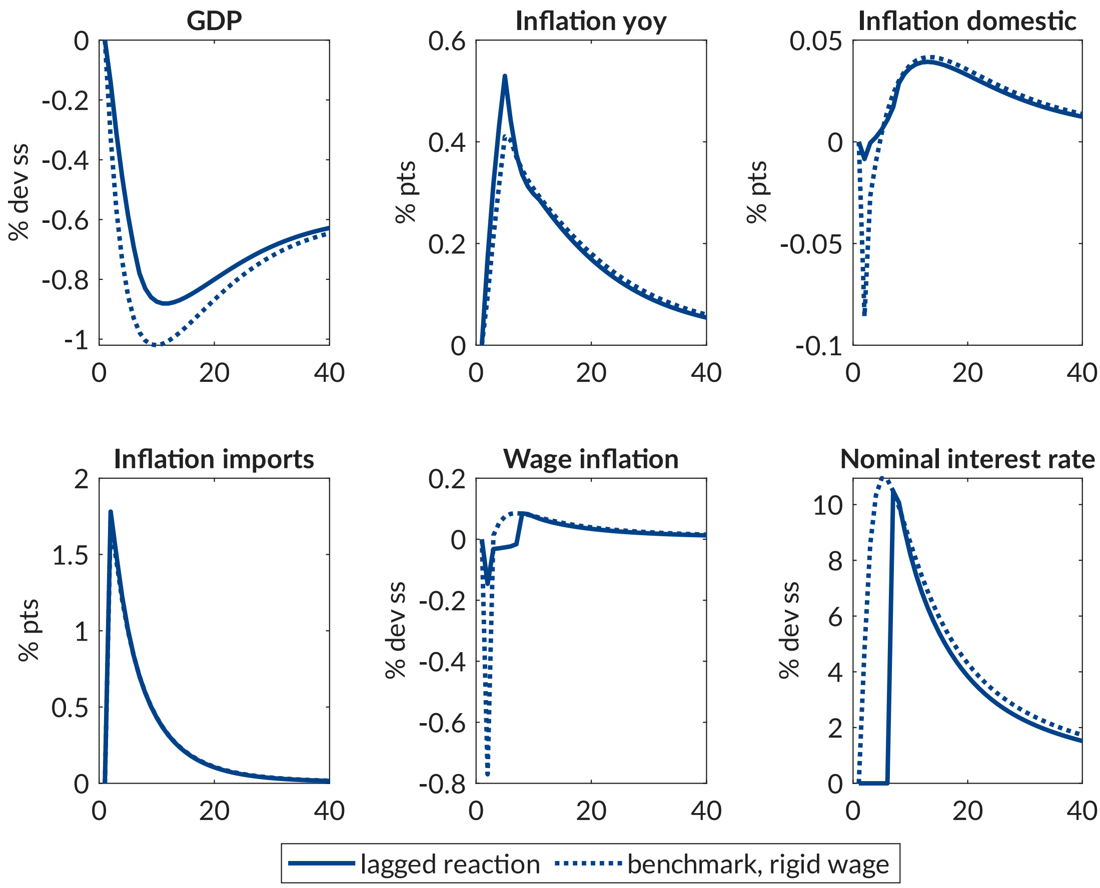
4 Conclusion

In this paper we have developed a three-country model that combines important features of international trade models and macroeconomic models, allowing us to provide meaningful simulations of the adjustment process to trade fragmentation shocks. We calibrate the model to match three geostrategic blocs and model trade fragmentation as an increase in trade costs between the West and the East, while trade costs vis-a-vis a neutral bloc remain unchanged. Our research is part of a bigger project of the International Relations Committee of the Eurosystem that provides a comprehensive analysis of trade fragmentation (see Attinasi et al., 2024).

We find that nominal rigidities play an important role in shaping the adjustment process. Trade fragmentation can push up inflation substantially and very persistently, while nominal rigidities slow down the adjustment process and lead to stronger losses in GDP. A more detailed analysis of nominal rigidities reveals that the assumption of local currency pricing (invoicing in the consumer's currency) implies smaller but more persistent increases in inflation (compared to producer currency pricing). Nominal wage rigidity, in turn, is responsible for stronger second-round effects and more persistent effects on the inflation of

Chart 9

Effects of an increase in trade costs on the Western bloc for lagged reaction of monetary policy



Note: Quarters on the horizontal axis, percent (point) deviations from steady state on the vertical axis.
Source: Authors' calculations.

domestically produced goods.

Nominal rigidity also implies that monetary policy can influence the adjustment process. By following a more contractionary monetary policy, the central bank can dampen the increase in inflation but at the cost of a substantially deeper recession. Monetary policy that reacts more strongly to the output gap can reduce the magnitude of the recession, but at the cost of much higher inflation. In contrast, monetary policy that stays inactive for some limited time can reduce the losses in GDP at the cost of only mildly higher inflation. This supports the view that monetary policy should "look through" supply shocks.

In line with the IRC report, we have concentrated on non-tariff trade costs to model the fragmentation of the world trading system into three blocs. In light of recent events and policy changes there are certainly other fragmentation scenarios one could consider. For one, the current US administration under President Trump certainly seems to favor imports tariffs over non-tariff trade barriers. Second, the Trump administration has threatened many of its allies that are in the same Western bloc in our analysis with tariffs as well. We consider these scenarios as fruitful avenues for future research.

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A Appendix: Model

In the following sections we describe all the decision problems for the neutral bloc N; equivalent equations hold for the Western and Eastern blocs W and E, and superscripts N, W and E pertain to variables in the N, W and E bloc, respectively.

A.1 Households

The representative household chooses consumption C_t and labor hours L_t optimally based on the following utility function

$$\sum_{k=0}^{\infty} \beta^k N^N \left[\frac{1}{1-\sigma} \left(\frac{C_{t+k}^N}{N^N} - \nu \frac{C_{t+k-1}^N}{N^N} \right)^{1-\sigma} - \frac{(L_{t+k}^N)^{1+\vartheta}}{1+\vartheta} \right], \tag{1}$$

where N^N is the fixed population of workers, $0 \leq \nu \leq 1$ is the habit intensity parameter, $\sigma > 0$ is the inverse of the intertemporal elasticity of substitution, and $\vartheta > 0$ is a Frisch elasticity parameter.[14] Household preferences are subject to the following period budget constraint written in real terms

$$C_t^N + I_t^N + A_t^{NN} + Q_t^{NW} A_t^{NW} + Q_t^{NE} A_t^{NE} + \frac{\zeta}{2}(A_t^{NN})^2 + Q_t^{NW}\frac{\zeta}{2}(A_t^{NW})^2 + Q_t^{NE}\frac{\zeta}{2}(A_t^{NE})^2 = r_{k,t}^N K_{t-1}^N + W_t^N L_t^N N^N$$
$$+ \frac{A_{t-1}^{NW}(1+i_{t-1}^N)}{1+\pi_t^N} + Q_t^{NW}\frac{A_{t-1}^{NW}(1+i_{t-1}^W)}{1+\pi_t^W} + Q_t^{NE}\frac{A_{t-1}^{NE}(1+i_{t-1}^E)}{1+\pi_t^E} + T_t^N + d_t^{r,N} + d_t^{p,N}. \tag{2}$$

The left-hand side includes total household expenditure on consumption C_t^N and investment I_t^N goods in period t, and N-household holdings of real N-bonds A_t^{NN}, real W-bonds A_t^{NW} and real E-bonds A_t^{NE} at the end of period t. W-bonds are in terms of W-consumption and thus adjusted for the real exchange rate $Q_t^{NW} \equiv e_t^{NW} P_t^W / P_t^N$, defined as the relative price of W-goods versus N-goods, with e_t^{NW} being the nominal exchange rate which describes how many units of N-currency are needed to buy one unit of W-currency. Similarly, E-bonds are denominated in terms of E-consumption with $Q_t^{NE} \equiv e_t^{NE} P_t^E / P_t^N$ and e_t^{NE} in units of N-currency per unit of E-currency.

When purchasing bonds, households have to pay a quadratic adjustment cost for N-bonds $\frac{\zeta}{2}(A_t^{NN})^2$, W-bonds $Q_t^{NW}\frac{\zeta}{2}(A_t^{NW})^2$ and E-bonds $Q_t^{NE}\frac{\zeta}{2}(A_t^{NE})^2$.[15] These costs are paid to financial intermediaries whose only function is to collect these transaction fees and rebate the revenue to households in lump-sum fashion where the rebate is $T_t^N = \frac{\zeta}{2}(A_t^{NN})^2 + Q_t^{NW}\frac{\zeta}{2}(A_t^{NW})^2 + Q_t^{NE}\frac{\zeta}{2}(A_t^{NE})^2$. The right-hand side of the equation includes sources of income such as income from renting out capital $r_{k,t}K_{t-1}$ to firms, wage income $W_t^N L_t^N N^N$, interest income on N-bond holdings $\frac{A_{t-1}^{NN}(1+i_{t-1})}{1+\pi_t^N}$, W-bond holdings $Q_t^{NW}\frac{A_{t-1}^{NW}(1+i_{t-1}^W)}{1+\pi_t^W}$, E-bond holdings $Q_t^{NE}\frac{A_{t-1}^{NE}(1+i_{t-1}^E)}{1+\pi_t^E}$, profit transfers from owning retail and intermediate firms $d_t^{r,N}$ and $d_t^{p,N}$ (to be defined in more detail below), and the bond cost rebate T_t^N. i_{t-1}^N, i_{t-1}^W and i_{t-1}^E are the nominal interest rates on N, W and E bond holdings converted in real terms by adjusting for inflation at N π_t^N, at W π_t^W and at E π_t^E.

Households invest and hold physical capital and rent it to the firms. Capital is subject to investment

[14] We use population N to calibrate the size of the country-blocs and hours L as an endogenous adjustment margin over the business cycle.

[15] These kinds of bond adjustment costs are a way to pin down a unique steady state, see Schmitt-Grohe and Uribe (2003).

adjustment costs as in Christiano et al. (2005) and accumulates according to

$$K_t^N = (1-\delta_k)K_{t-1}^N + I_t^N\left[1 - \frac{\gamma_k}{2}(\frac{I_t^N}{I_{t-1}^N} - 1)^2\right], \tag{3}$$

where $0 < \delta_k < 1$ is the depreciation rate, and $\gamma_k > 0$ is an investment cost adjustment parameter.

The household optimization problem implies the following marginal utility of consumption

$$U_{c,t}^N = (C_t^N - \nu C_{t-1}^N)^{-\sigma}, \tag{4}$$

and Euler equations with respect to N-, W- and E-bonds

$$U_{c,t}^N(1+\zeta A_t^{NN}) = \beta U_{c,t+1}^N \frac{(1+i_t^N)}{(1+\pi_{t+1}^N)}, \tag{5}$$

$$U_{c,t}^N(1+\zeta A_t^{NW}) = \beta U_{c,t+1}^N \frac{(1+i_t^W)}{(1+\pi_{t+1}^W)} \frac{Q_{t+1}^{NW}}{Q_t^{NW}}, \tag{6}$$

$$U_{c,t}^N(1+\zeta A_t^{NE}) = \beta U_{c,t+1}^N \frac{(1+i_t^E)}{(1+\pi_{t+1}^E)} \frac{Q_{t+1}^{NE}}{Q_t^{NE}}. \tag{7}$$

Similarly, we obtain the optimal conditions for physical capital

$$U_{c,t+1}^N r_{k,t+1}^N + (1-\delta_k)\lambda_{k,t+1}^N - \frac{\lambda_{k,t}^N}{\beta} = 0, \tag{8}$$

and investment

$$U_{c,t}^N = \lambda_{k,t}^N\left[1 - \frac{\gamma_k}{2}(\frac{I_t^N}{I_{t-1}^N} - 1)^2 - \frac{I_t^N}{I_{t-1}^N}\gamma_k(\frac{I_t^N}{I_{t-1}^N} - 1)\right] + \beta\lambda_{k,t+1}^N\kappa_{t+1}(\frac{I_{t+1}^N}{I_t^N})^2\gamma_k(\frac{I_{t+1}^N}{I_t^N} - 1), \tag{9}$$

where $\lambda_{k,t}$ is the Lagrange multiplier on the capital accumulation equation.

To be able to consider nominal wage rigidity, we suppose that workers produce a slightly differentiated labor input and sell it under monopolistic competition. Assuming a linear production technology, workers maximize the following expected profits:

$$d_t^{w,N} = \sum_{s=t}^{\infty}\beta\frac{U_{c,s+1}^N}{U_{c,s}^N}\left[W_{i,s}^N L_{i,s}^N - \frac{\frac{(L_{i,s}^N)^{(1+\vartheta)}}{1+\vartheta}}{U_{c,s}^N} - \chi^w\left(1+\pi_t^{w,N}\right)^2 W_{i,s}^N L_{i,s}^N\right], \tag{10}$$

subject to the demand function

$$L_{i,t}^N = \left(\frac{W_{i,t}^N}{W_t^N}\right)^{-\phi^w} L_t^N, \tag{11}$$

where χ^w is a wage cost adjustment parameter, ϕ^w is the elasticity of substitution between differentiated intermediate labor inputs and π_t^w is nominal wage inflation. Assuming symmetric workers, the above optimization problem implies the following optimal labor supply condition:

$$\frac{\left(L_t^N\right)^{\vartheta}}{U_{c,t}^N}\phi^w = W_t^N\left[\chi^w\pi_t^{w,N}(\pi_t^{w,N}+1)-(1-\phi^w)(1-\frac{\chi^w}{2}\left(\pi_t^{w,N}\right)^2)\right.$$
$$\left. -\beta\frac{U_{c,s+1}^N}{U_{c,s}^N}\chi^w(\pi_{t+1}^{w,N}+1)^2\frac{\pi_{t+1}^{w,N}}{\pi_{t+1}^N+1}\frac{L_{t+1}^N}{L_t^N}\right]. \quad (12)$$

Note that assuming flexible wages, i.e. $\chi^w = 0$ renders the familiar optimal labor supply condition

$$W_t^N = \frac{\left(L_t^N\right)^{\vartheta}}{U_{c,t}^N}\frac{\phi^w}{\phi^w-1}. \quad (13)$$

A.2 Production

The model features a two-tier production structure which separates a firm's entry decision and selection into export markets from nominal rigidity in a tractable way. First, we describe production in the intermediate goods sector where firm entry and selection into export prices take place and then we describe the retail sector where the price-setting decision is subject to adjustment costs.

A.2.1 Intermediate goods sector

The producers of intermediate goods are heterogeneous firms subject to firm entry frictions as in Ghironi and Melitz (2005). They sell their products to the retailers that are situated in their domestic country. The output of the production sector is a bundle defined over a continuum of varieties Ω:

$$Y_{d,t}^N = \left[\int_{\omega\epsilon\Omega^N} y_t^{p,N}(\omega)^{\frac{\theta-1}{\theta}}d\omega\right]^{\frac{\theta}{\theta-1}}, \quad (14)$$

$$Y_{x,t}^{NW} = \left[\int_{\omega\epsilon\Omega_x^{NW}} y_t^{p,N}(\omega)^{\frac{\theta-1}{\theta}}d\omega\right]^{\frac{\theta}{\theta-1}}, \quad (15)$$

$$Y_{x,t}^{NE} = \left[\int_{\omega\epsilon\Omega_x^{NE}} y_t^{p,N}(\omega)^{\frac{\theta-1}{\theta}}d\omega\right]^{\frac{\theta}{\theta-1}}, \quad (16)$$

where $\theta > 0$ is the elasticity of substitution between varieties. These varieties are not traded internationally but are sold only to domestic retailers. Nevertheless, to make a product suitable for exporting by a retailer the producer needs to pay a fixed exporting cost which is different for W ($f_{x,t}^{NW}$) and E ($f_{x,t}^{NE}$). Thus the set of varieties suitable for exporting $\Omega_{x,t}^{NW}$ to W is different from the set $\Omega_{x,t}^{NE}$ exported to E and from the set Ω_t^N sold domestically. Due to endogenous varieties, the price index is again different for domestic retailers $P_{d,t}^{p,N} = \left[\int_{\omega\epsilon\Omega^N} p_{d,t}^{p,N}(\omega)^{1-\theta}d\omega\right]^{\frac{1}{1-\theta}}$, export retailers for W, $P_t^{p,NW} = \left[\int_{\omega\epsilon\Omega_x^{NW}} p_{xt}^{p,NW}(\omega)^{1-\theta}d\omega\right]^{\frac{1}{1-\theta}}$, and for E, $P_{xt}^{p,NE} = \left[\int_{\omega\epsilon\Omega_x^{NE}} p_{x,t}^{p,NE}(\omega)^{1-\theta}d\omega\right]^{\frac{1}{1-\theta}}$.

The three demand functions faced by intermediate producers are

$$y_{d,t}^{p,N}(\omega) = \left(\frac{p_{d,t}^{p,N}(\omega)}{P_t^{p,N}}\right)^{-\theta} Y_{d,t}^{p,N},$$
$$y_{x,t}^{p,NW}(\omega) = \left(\frac{p_{x,t}^{p,NW}(\omega)}{P_{x,t}^{p,NW}}\right)^{-\theta} Y_{x,t}^{NW},$$
$$y_{x,t}^{p,NE}(\omega) = \left(\frac{p_{x,t}^{p,NE}(\omega)}{P_{x,t}^{p,NE}}\right)^{-\theta} Y_{x,t}^{NE}.$$

The number of firms producing intermediate goods is endogenous. At each point in time, only a subset of varieties $\Omega_t^N \in \Omega$ comprising the domestic bundle is actually available to consumers. To start producing, a firm needs to undertake a sunk investment, f_e, in effective labor units. In the spirit of Melitz (2003) each firm operates at different productivity z. The firm uses both labor and physical capital to produce a variety. The production technology is assumed to be Cobb-Douglas in the two inputs of production:

$$y_t^N(\omega) = Z_t^N z(\omega) \left(K_{it-1}^N(\omega)\right)^{\beta_K} \left(L_{it}^N(\omega)N^N\right)^{(1-\beta_K)} \tag{17}$$

where Z_t^N is aggregate productivity, $z(\omega)$ is firm-specific productivity, $K_{t-1}^N(\omega)$ is the amount of capital used by the firm, and $L_t^N(\omega)N^N$ is the amount of hours used by the firm, $0 < \beta_{Ki} < 1$ is the share of capital required by a firm to produce one unit of output y_t^N of variety ω. The real marginal cost faced by each firm is $mc_t^N(\omega) = \left(r_{k,t}^N\right)^{\beta_K} \left(W_t^N\right)^{(1-\beta_{Ki})} / (Z_t^N z^N(\omega))$. Capital and labor are perfectly mobile across firms which implies that all firms pay the same wage and the same rental rate of capital. Consequently, relative capital demand can be described by the following condition:

$$\frac{r_{k,t}^N}{W_t^N} = \frac{\beta_k}{1-\beta_k} \frac{N^N L_t^N(\omega)}{K_{t-1}^N(\omega)} \tag{18}$$

This condition says that the ratio of the rental rate to the real wage is equal to the ratio of the marginal contribution of each factor to producing one additional unit of output. Note that this condition implies that the relative demand for labor and capital is the same across firms.

We assume that all firms in a given country are owned by the household which also invests in new firms and receives the surplus of profits over firm investment in a lump-sum fashion. To set up a new firm the sunk entry cost $f_e^N W_t^N$ has to be paid. Note that entry costs are the same for all firms.

All firms are subject to exit shocks, which occur with probability $\delta \in (0, 1)$ at the end of each period. We assume that entrants at time t only start producing at time $t+1$, which introduces a one-period time-to-build lag in the model. Thus, a proportion δ of new entrants will never produce. At time t, the number of domestic firms is M_t^N and the number of newly entered firms is $M_{e,t}^N$. Then the law of motion for the stock of producing firms can be written as:

$$M_t^N = (1-\delta)(M_{t-1}^N + M_{e,t-1}^N). \tag{19}$$

The present discounted value of expected profits is

$$V_t^N = \sum_{s=t+1}^{\infty} \left[\beta^{s-t} (1-\delta)^{s-t} \left(\frac{U_{c,s}^N}{U_{c,t}^N} \right) d_{is}^{p,N} \right]. \tag{20}$$

Firm profits, d^p, are discounted using the aggregate stochastic discount factor adjusted for the probability of firm survival $(1-\delta)$. Note that equation 20 can be written in recursive form as:

$$V_t^N = \beta(1-\delta) \frac{U_{c,t+1}^N}{U_{c,t}^N} (V_{t+1}^N + d_{t+1}^{p,N}) \tag{21}$$

Entry occurs until firm value is equal to the entry cost:

$$V_t^N = \frac{f_e^N \left(W_t^N \right)}{Z_t^N}. \tag{22}$$

The productivity level z of each firm is drawn from a common Pareto distribution $G(z)$ with minimum $z_{min} > 0$ and a shape parameter $k_p > 0$.

Firms operate in a monopolistically competitive market and set their prices $p_t(z)^N$ at a constant markup $\frac{\theta}{\theta-1}$ over marginal cost. Producing a variety to be sold to retailers which export involves a fixed export cost denominated in effective labor units where $f_{x,t}^{NW} W_t^N$ is the fixed export cost for W and $f_{x,t}^{NE} W_t$ is the fixed export cost for E. This gives rise to selection into export markets separately for N and W, that is, only a subset of firms is productive enough to generate positive profits from exporting to W (with $z > \Psi_t^{NW}$) and to E (with $z > \Psi_t^{NE}$).

All producers charge the same markup, but prices can still differ due to differences in productivity. Profits, expressed in units of the aggregate consumption bundle of the firm's location are $d_t^N(z) = d_{d,t}^N(z) + d_{x,t}^{NW}(z) + d_{x,t}^{NE}(z)$, where

$$d_{d,t}^{p,N}(z) = \frac{1}{\theta} \left(\frac{p_t^{p,N}(z)}{P_{d,t}^{p,N}} \right)^{1-\theta} Y_{d,t}^N \tag{23}$$

$$d_{x,t}^{p,NW}(z) = \begin{cases} \frac{1}{\theta} \left(\frac{p_t^{p,NW}(z)}{P_{x,t}^{p,NW}} \right)^{1-\theta} Y_{x,t}^{NW} - f_{x,t}^{NW} W_t^N, & \text{if firm z exports to W} \\ 0 & \text{otherwise,} \end{cases} \tag{24}$$

$$d_{x,t}^{p,NE}(z) = \begin{cases} \frac{1}{\theta} \left(\frac{p_t^{p,NE}(z)}{P_{x,t}^{p,NE}} \right)^{1-\theta} Y_{x,t}^{NE} - f_{x,t}^{NE} W_t^N, & \text{if firm z exports to E} \\ 0 & \text{otherwise,} \end{cases} \tag{25}$$

A firm will export if and only if it earns non-negative profits from doing so.

Specifically, the share of exporting firms for W is $X_t^{NW} = [1 - G(\Psi_t^{NW})]$ and for E is $X_t^{NE} = [1 - G(\Psi_t^{NE})]$,, where the Pareto distribution implies that

$$X_t^{NW} = \left(\frac{z_{min}}{\Psi_t^{NW}} \right)^{k_p} \tag{26}$$

$$X_t^{NE} = \left(\frac{z_{min}}{\Psi_t^{NE}} \right)^{k_p} \tag{27}$$

where Ψ_t^{NW} and Ψ_t^{NE} are the minimum threshold levels of productivity required for a firm to produce an exported variety for W and E, respectively.

Due to selection into export markets, the composition of the exported set of varities for W, $Y_{x,t}^{NW} = \left[\int_{\Psi_t^{NW}}^{\infty} y_{x,t}^{NW}(z)^{\frac{\theta-1}{\theta}} M_t^N G(z)dz\right]^{\frac{\theta}{\theta-1}}$, is different from the one for E, $Y_{x,t}^{NE} = \left[\int_{\Psi_t^{NE}}^{\infty} y_{x,t}^{NE}(z)^{\frac{\theta-1}{\theta}} M_t^N G(z)dz\right]^{\frac{\theta}{\theta-1}}$, and the domestic one, $Y_{d,t}^{N} = \left[\int_{z_{min}}^{\infty} y_{d,t}^{N}(z)^{\frac{\theta-1}{\theta}} M_t^N G(z)dz\right]^{\frac{\theta}{\theta-1}}$. In addition, the real marginal cost firms pay to produce the export bundle to W $mc_{x,t}^{NW} = \left[\int_{\Psi_t^{NW}}^{\infty} mc_t^N(z)^{1-\theta} G(z)dz\right]^{\frac{1}{1-\theta}}$ is different from the cost paid to produce the export bundle for E $mc_{x,t}^{NE} = \left[\int_{\Psi_t^{NE}}^{\infty} mc_t^N(z)^{1-\theta} G(z)dz\right]^{\frac{1}{1-\theta}}$ and the domestic bundle $mc_{d,t}^{N} = \left[\int_{z_{min}}^{\infty} mc_t^N(z)^{1-\theta} G(z)dz\right]^{\frac{1}{1-\theta}}$.

It is useful to define the average productivity levels that characterize domestic and exporting firms: an average $z_{d,t}^N$ for all firms producing domestic varieties, and an average $z_{x,t}^{NW}$ for all firms producing export varieties for W and $z_{x,t}^{NE}$ for E:

$$z_d^N = \left[\int_{z_{min}}^{\infty} z^{\theta-1} dG(z)\right]^{\frac{1}{(\theta-1)}} = \left(\frac{k_p}{\gamma}\right)^{\frac{1}{\theta-1}} z_{min}, \tag{28}$$

$$z_{x,t}^{NW} = \left[\int_{\Psi_t^{NW}}^{\infty} z^{\theta-1} dG(z)\right]^{\frac{1}{(\theta-1)}} = \left(\frac{k_p}{\gamma}\right)^{\frac{1}{\theta-1}} \Psi_t^{NW}, \tag{29}$$

$$z_{x,t}^{NE} = \left[\int_{\Psi_t^{NE}}^{\infty} z^{\theta-1} dG(z)\right]^{\frac{1}{(\theta-1)}} = \left(\frac{k_p}{\gamma}\right)^{\frac{1}{\theta-1}} \Psi_t^{NE}, \tag{30}$$

where $\gamma = k_p - (\theta - 1)$. As in Melitz (2003), these average productivity levels summarize all the necessary information about the productivity distributions of intermediate firms. We can re-write marginal costs on the domestic bundle and the output bundle in terms of average productivities such that $mc_{d,t}^N = \frac{(W_t^N)^{1-\beta_k}\left(r_{k,t}^N\right)^{\beta_k}}{Z_t^N z_{d,t}^N}$, $mc_{x,t}^{NW} = \frac{(W_t^N)^{1-\beta_k}\left(r_{k,t}^N\right)^{\beta_k}}{Z_t^N z_{x,t}^{NW}}$ and $mc_{x,t}^{NE} = \frac{(W_t^N)^{1-\beta_k}\left(r_{k,t}^N\right)^{\beta_k}}{Z_t^N z_{x,t}^{NE}}$.

Optimal price setting implies that firms charge a constant markup $\frac{\theta}{\theta-1}$ over their marginal cost so that the average price expressed in units of the aggregate consumption bundle is:

$$VPD_t^N = \frac{p_t^{p,N}(z_d^N)}{P_t^N} = \frac{\theta}{\theta-1} \frac{\left(W_t^N\right)^{1-\beta_k}\left(r_{k,t}^N\right)^{\beta_k}}{Z_t^N z_{d,t}^N} \tag{31}$$

$$VPX_t^{NW} = \frac{p_t^{p,NW}(z_{x,t}^{NW})}{P_t^N} = \frac{\theta}{\theta-1} \frac{\left(W_t^N\right)^{1-\beta_k}\left(r_{k,t}^N\right)^{\beta_k}}{Z_t^N z_{x,t}^{NW}}, \tag{32}$$

$$VPX_t^{NE} = \frac{p_t^{p,NE}(z_{x,t}^{NE})}{P_t^N} = \frac{\theta}{\theta-1} \frac{\left(W_t^N\right)^{1-\beta_k}\left(r_{k,t}^N\right)^{\beta_k}}{Z_t^N z_{x,t}^{NE}}, \tag{33}$$

where VPD_t^N is the average price of producers of domestic varieties and VPX_t^{NW} and VPX_t^{NE} are the average prices of producers of an exported varieties for W and E, respectively. We can also define the average output produced for the domestic bundle VYD_t^N and the export bundles VYX_t^{NW} and VYX_t^{NE} as a function of the number of producers and the total set of varieties produced (including the iceberg trade costs τ^{NW} and τ^{NE}):

$$VYD_t^N = (M_t^N)^{\frac{\theta}{1-\theta}} Y_{d,t}^N, \tag{34}$$

$$VYX_t^{NW} = (M_t^N X_t^{NW})^{\frac{\theta}{1-\theta}} \tau^{NW} Y_{x,t}^{NW}, \tag{35}$$

$$VYX_t^{NE} = (M_t^N X_t^{NE})^{\frac{\theta}{1-\theta}} \tau^{NE} Y_{x,t}^{NE}. \tag{36}$$

Profits of the intermediate goods sector that are rebated to households are then:

$$d_t^{p,N} = \frac{1}{\theta} VPD_t^N VYD_t^N + X_t^{NW} \left(\frac{1}{\theta} VPX_t^{NW} VYX_t^{NW} - \frac{W_t^N}{Z_t^N} f_{x,t}^{NW} \right) + X_t^{NE} \left(\frac{1}{\theta} VPX_t^{NE} VYX_t^{NE} - \frac{W_t^N}{Z_t^N} f_{x,t}^{NE} \right) \tag{37}$$

Finally, labor demand from the intermediate goods sector implies the following labor market clearing condition:

$$L_t^N N^N = \frac{M_t^N}{Z_t^N} \left(\frac{1-\beta_k}{\beta_k} \frac{r_{k,t}^N}{W_t^N} \right)^{\beta_k} \left(\frac{VYD_t^N}{z_{d,t}^N} + \frac{VYX_t^{NW}}{z_{x,t}^{NW}} X_t^{NW} + \frac{VYX_t^{NE}}{z_{x,t}^{NE}} X_t^{NE} \right) + M_{e,t}^N \frac{f_{e,t}^N}{Z_t^N} + M_t^N X_t^{NW} \frac{f_{x,t}^{NW}}{Z_t^N} + M_t^N X_t^{NE} \frac{f_{x,t}^{NE}}{Z_t^N}, \tag{38}$$

where the left side refers to labor supply while the right side refers to labor demand for the production of intermediate goods for retailers who serve the domestic and foreign markets, for investment in new intermediate firms and the fixed cost of intermediate firms serving the retailers which export.

A.3 Retail sector

Retailers buy the products produced by the production sector, bundle them into consumption goods and sell them to domestic and foreign consumers and capital investors. The retail sector is subject to nominal rigidities as we follow Rotemberg (1982) and assume that firms must pay quadratic price adjustment costs when changing prices. First, we describe the problem of the retailers serving the domestic market and then the problem of retailers serving the foreign market.

A.3.1 Domestic market

Retail firms that serve the domestic market aggregate the intermediate bundles according to the following CES technology

$$Y_{dt}^N = \left(\int_0^1 Y_{d,t}^{r,N}(j)^{\frac{\phi^N - 1}{\phi^N}} dj \right)^{\frac{\phi^N}{\phi^N - 1}}, \tag{39}$$

with elasticity of substitution $\phi^N > 0$ between bundles. It implies the following retail price index and demand function

$$P_{d,t}^N = (\left(\int_0^1 P_{d,t}^{r,N}(j)^{1-\phi^N} dj \right)^{\frac{1}{1-\phi^N}}), \tag{40}$$

$$Y_{d,t}^{r,N}(j) = \left(\frac{P_{d,t}^{r,N}(j)}{P_{d,t}^{N}} \right)^{-\phi^N} Y_{d,t}^{N}. \tag{41}$$

The firm wants to maximize expected profits $d_{d,t}^{r,N}(j)$

$$d_{d,t}^{r,N}(j) = E_t \sum_{s=t}^{\infty} \beta \frac{U_{c,t+1}^N}{U_{c,t}^N} \left[\frac{P_{d,s}^{r,N}(j)}{P_s^N} Y_{d,s}^{r,N}(j) - \frac{P_{d,s}^{p,N}}{P_s^N} Y_{d,s}^{r,N}(j) - \frac{\chi}{2} \left(\frac{P_{d,s}^{r,N}(j)}{P_{d,s-1}^{r,N}(j)} - 1 \right)^2 \frac{P_{d,s}^{r,N}(j)}{P_s^N} Y_{d,s}^{r,N}(j) \right]$$

where $P_{d,t}^N(j)$ is the price that retailer j is charging domestic consumers and capital investors, $P_{d,t}^{p,N}$ is the price of the producer-bundle which serves as the input cost of the retailers, $Y_{d,t}^{r,N}(j)$ is the output sold by domestic retailers, and $\chi > 0$ is a parameter that determines the magnitude of the price adjustment costs. We assume that retail firms discount their profits using the same discount factor as the households. The firm chooses $P_{d,t}^{r,N}(j)$ to maximize profits subject to its demand function. In equilibrium, all retail firms behave identically since all face the same demand function, pay the same marginal and price adjustment costs, implying that $P_{d,t}^{r,N}(j) = P_{d,t}^{r,N} = P_{d,t}^N$ and $Y_{d,t}^{r,N}(j) = Y_{d,t}^{r,N} = Y_{d,t}^N$. The optimal price that retail firms charge domestic households is set at a markup over marginal cost:

$$\frac{P_{d,t}^N}{P_t^N} = \mu_{d,t}^N \frac{P_{d,t}^{p,N}}{P_t^N} = VPD_t^N \mu_{d,t}^N \left(M_t^N \right)^{\frac{1}{1-\theta}}, \tag{42}$$

where the optimal markup is

$$\mu_{d,t}^N = \frac{\phi^N}{\left[(\phi^N - 1) \left(1 - \frac{\chi}{2} \left(\pi_{d,t}^N \right)^2 \right) + \chi \pi_{d,t}^N \left(\pi_{d,t}^N + 1 \right) - \beta \frac{U_{c,t+1}^N}{U_{c,t}^N} \chi \pi_{d,t+1}^N \left(\pi_{d,t+1}^N + 1 \right)^2 \frac{1}{\pi_{t+1}^N + 1} \frac{Y_{d,t+1}^N}{Y_{d,t}^N} \right]}. \tag{43}$$

Profits are given by

$$d_{d,t}^{r,N} = \left(\frac{\mu_{d,t}^N - 1}{\mu_{d,t}^N} \right) \frac{P_{d,t}^N}{P_t^N} Y_{d,t}^N - \frac{\chi}{2} \left(\pi_{d,t}^N \right)^2 \frac{P_{d,t}^N}{P_t^N} Y_{d,t}^N$$

and final demand for a domestic variety is

$$Y_{d,t}^N = \left(\frac{P_{d,t}^N}{P_t^N} \right)^{-\phi^N} Y_t^N, \tag{44}$$

where $Y_t^N = C_t^N + I_t^N$ is total demand for the final retail good for consumption and investment.

A.3.2 Foreign markets

For brevity, we only present the problem of retailers exporting to W. Exporters to E solve an equivalent problem and an equivalent set of equations hold for them. The mass of retail firms that sell to W aggregate the intermediate bundles meant for export goods according the following CES technology:

$$Y_{xt}^{NW} = \left(\int_0^1 Y_{x,t}^{r,NW}(j)^{\frac{\phi^W - 1}{\phi^W}} dj \right)^{\frac{\phi^W}{\phi^W - 1}}, \tag{45}$$

which implies the following corresponding price index and demand function for exports to W,

$$P_{x,t}^{NW} = \left(\int_0^1 P_{x,t}^{r,NW}(j)^{1-\phi^W} dj \right)^{\frac{1}{1-\phi^W}}, \tag{46}$$

$$Y_{x,t}^{r,NW}(j) = \left(\frac{P_{x,t}^{r,NW}(j)}{P_{x,t}^{NW}} \right)^{-\phi^W} Y_{x,t}^{NW}. \tag{47}$$

We assume local currency pricing (LCP) so that foreign prices are set in the currency of destination, but as robustness we will also consider producer currency pricing (PCP). Denote the price that retail export firms receive in their own currency as $P_{x,t}^{rh,NW}(j)$. To export, the retailers have to pay an iceberg trade cost τ_t^{NW}. Then, the price that foreign consumers and capital investors pay is $P_{x,t}^{r,NW}(j) = P_{x,t}^{rh,NW}(j)\tau_t^{NW}/e_t^{NW}$. Note that $P_{x,t}^{r,NW}$ is also the price in which price adjustment costs are invoiced. A retail firm j serving the foreign market has the following profits:

$$d_{x,t}^{r,NW}(j) = \sum_{s=t}^{\infty} \beta \frac{U_{c,t+1}^N}{U_{c,t}^N} \left[\frac{P_{x,t}(j)^{r,NW} e_t^{NW}}{P_s} Y_{x,s}^{r,NW}(j) - \frac{P_{x,s}^{P,NW}}{P_s} \tau_t^{NW} Y_{x,s}^{r,NW}(j) \right.$$
$$\left. - \frac{\chi}{2} \left(\frac{P_{x,s}^{r,NW}(j)}{P_{x,s-1}^{r,NW}(j)} - 1 \right)^2 \frac{P_{x,t}(j)^{r,NW} e_t^{NW}}{P_s} Y_{x,s}^{r,NW}(j) \right] \tag{48}$$

where $P_{x,s}^{P,NW}$ is the price for the producer-bundle meant for export to W, and $Y_{x,s}^{r,NW}(j)$ is the amount sold to W. Note that due to the iceberg trade cost the firm has to ship $\tau_t^{NW} Y_{x,t}^{r,NW}(j)$ in order to sell $Y_{x,t}^{r,NW}(j)$. The firm chooses $P_{x,t}^{r,NW}(j)$ to maximize profits subject to its demand function. In equilibrium all retail firms serving the W-market behave identically since all face the same demand function, and pay the same marginal and price adjustment costs, implying that $P_{x,t}^{r,NW}(j) = P_{x,t}^{r,NW} = P_{x,t}^{NW}$ and $Y_{x,t}^{r,NW}(j) = Y_{x,t}^{r,NW} = Y_{x,t}^{NW}$. The optimal price that retail firms charge foreign households is set at a markup over marginal cost,

$$\frac{P_{x,t}^{NW}}{P_t^W} = \frac{\tau_t^{NW}}{Q_t^{NW}} \mu_{x,t}^{NW} \frac{P_{x,s}^{P,NW}}{P_t^N},$$

and the optimal markup $\mu_{x,t}^{NW}$ is:

$$\mu_{x,t}^{NW} = \frac{\phi^W}{\left[(\phi^W - 1)\left(1 - \frac{\chi}{2}\left(\pi_{x,t}^{imp,NW}\right)^2\right) + \chi(\pi_{x,t}^{imp,NW} + 1)\pi_{x,t}^{imp,NW} - \chi\beta \frac{U_{c,t+1}^N}{U_{c,t}^N} (\pi_{x,t+1}^{imp,NW} + 1)^2 \frac{\pi_{x,t+1}^{imp,NW}}{\pi_{t+1}^W + 1} \frac{Q_{t+1}^{NW}}{Q_t^{NW}} \frac{Y_{x,t+1}^{NW}}{Y_{x,t}^{NW}} \right]}$$

Profits are given by

$$d_{x,t}^{r,NW} = \left(\frac{\mu_{x,t}^{NW} - 1}{\mu_{x,t}^{NW}} \right) \frac{P_{x,t}^{h,NW}}{P_t^N} Y_{x,t}^{NW} - \frac{\chi}{2} \left(\pi_{x,t}^{imp,NW}\right)^2 \frac{P_{x,t}^{h,NW}}{P_t} Y_{x,t}^{NW}.$$

and final demand for varieties exported to W is

$$Y_{x,t}^{NW} = \left(\frac{P_{xt}^{NW}}{P_t^W}\right)^{-\phi^W} Y_t^W + \frac{\chi}{2}\left(\pi_{x,t}^{imp,NW}\right)^2 Y_{x,t}^{NW} \tag{49}$$

Exporters to E solve an equivalent problem as the one presented above and an identical set of equations hold for them.

A.4 Monetary policy

In each country monetary policy is set according to a Taylor rule where the nominal interest rate i_t^N responds to fluctuations in inflation and GDP. The monetary rule in N is

$$(1+i_t^N) = (1+i_{t-1}^N)^{\upsilon_i}\left[(1+\pi_t^N)^{\upsilon_\pi}\left(1+\frac{GDP_t^N}{GDP^N})^{\upsilon_y}(1+i^N\right)\right]^{1-\upsilon_i}, \tag{50}$$

where υ_i is the interest rate smoothing parameter, υ_π is a parameter which characterizes the degree to which monetary policy responds to inflation and υ_y characterizes the degree to which the interest rate responds to fluctuations of GDP_t^N from its steady-state level.

A.5 International aggregation

The trade balance is defined as net exports $tb_t^N = EX_t^N - IM_t^N$ where exports and imports are given by

$$EX_t^N = EX_t^{NW}Q_t^{NW} + EX_t^{NE}Q^{NE} \text{ and } IM_t^N = EX_t^{WN} + EX_t^{EN}. \tag{51}$$

The markets for bonds must clear: $A_t^{NN} + A_t^{WN} + A^{EN} = 0$, implying the law of motion for net foreign assets:

$$A_t^{NN} + Q_t^{NW}A_t^{NW} + Q_t^{NE}A_t^{NE} = \frac{1+i_{t-1}}{1+\pi_t}A_t^{NN} + \frac{1+i_{t-1}^W}{1+\pi_t^W}A_{t-1}^{NW}Q_t^{NW} + \frac{1+i_{t-1}^E}{1+\pi_t^E}A_{t-1}^{NE}Q_t^{NE} + tb_t. \tag{52}$$

GDP in each country is defined as the total of aggregate demand: $GDP_t^N = C_t^N + I_t^N + tb_t^N$. Analogous equations hold for W and E.

A.6 Inflation and price aggregation

Our multi-stage production structure implies multiple inflation equations. The inflation for domestic bundles is

$$\frac{1+\pi_{d,t}^N}{1+\pi_t^N} = \frac{P_{d,t}^N/P_t^N}{P_{d,t-1}^N/P_{t-1}^N}. \tag{53}$$

The export inflation for bundles exported to W and to E is respectively,

$$\frac{1+\pi_{x,t}^{exp,NW}}{1+\pi_t^N} = \frac{P_{x,t}^{h,NW}/P_t^N}{P_{x,t-1}^{h,NW}/P_{t-1}^N}. \tag{54}$$

$$\frac{1+\pi_{x,t}^{exp,NE}}{1+\pi_t^N} = \frac{P_{x,t}^{h,NE}/P_t^N}{P_{x,t-1}^{h,NE}/P_{t-1}^N}. \tag{55}$$

The equivalents for import price inflation for the same bundles are:

$$\frac{1+\pi_{x,t}^{imp,NW}}{1+\pi_t^W} = \frac{P_{x,t}^{NW}/P_t^W}{P_{x,t-1}^{NW}/P_{t-1}^W}, \tag{56}$$

$$\frac{1+\pi_{x,t}^{imp,NE}}{1+\pi_t^E} = \frac{P_{x,t}^{NE}/P_t^E}{P_{x,t-1}^{NE}/P_{t-1}^E}. \tag{57}$$

We can define an import price index for N that is a weighted average for import price from W and the import price from E such that

$$\left(\frac{P_{m,t}^N}{P_t^N}\right)^{1-\phi^N} = \left(\frac{P_{x,t}^{WN}}{P_t^N}\right)^{1-\phi^N} + \left(\frac{P_{x,t}^{EN}}{P_t^N}\right)^{1-\phi^N}. \tag{58}$$

Import price inflation, then, is

$$\frac{1+\pi_{m,t}^N}{1+\pi_t^N} = \frac{P_{m,t}^N/P_t^N}{P_{m,t-1}^N/P_{t-1}^N}. \tag{59}$$

Note that all price indexes are measured in terms of the units of the final consumption such that

$$1 = \left(\frac{P_{d,t}^N}{P_t^N}\right)^{1-\phi^N} + \left(\frac{P_{m,t}^N}{P_t^N}\right)^{1-\phi^N}. \tag{60}$$

A.7 Producer currency pricing (PCP)

For our benchmark simulations we have assumed LCP so that foreign prices are set in the currency of the importing country. Here we modify the model to consider PCP where foreign prices are set in the currency of the exporting country. The assumption of PCP changes the terms related to the price adjustment costs which are no longer formulated in terms of the price in import currency but in terms of the export currency. Thus the price adjustment cost term which appears in equation 48 is now written as $\frac{\chi}{2}\left(\frac{P_{x,s}^{h,NW}}{P_{x,s-1}^{h,NW}}-1\right)^2$ instead of $\frac{\chi}{2}\left(\frac{P_{x,s}^{NW}}{P_{x,s-1}^{NW}}-1\right)^2$ Recall that $P_{x,t}^{h,NW} = P_{x,t}^{NW}e_t^{NW}/\tau_t^{NW}$. We can define export price inflation for the bundles exported to W and to E respectively, as $\pi_{x,t}^{exp,NW} = \frac{P_{x,t}^{h,NW}}{P_{x,t-1}^{h,NW}} - 1$ and $\pi_{x,t}^{exp,NE} = \frac{P_{x,t}^{h,NE}}{P_{x,t-1}^{h,NE}} - 1$. The changed pricing of course implies changes in the price setting condition for foreign markets, specifically the markup changes to

$$\mu_{x,t}^{NW} = \frac{\phi^W}{\left[(\phi^W-1)(1-\frac{\chi}{2}\left(\pi_{x,t}^{exp,NW}\right)^2) + \chi(\pi_{x,t}^{exp,NW}+1)\pi_{x,t}^{exp,NW} - \chi\beta\frac{U_{c,t+1}^N}{U_{c,t}^N}\left(\pi_{x,t+1}^{exp,NW}+1\right)^2\frac{\pi_{x,t+1}^{exp,NW}}{\pi_{t+1}^N+1}\frac{Y_{x,t+1}^{NW}}{Y_{x,t}^{NW}}\right]}.$$

B Appendix: Calibration

This section describes how we set the parameters of the model that we use for the numerical simulations.

We assume that all three countries are symmetric except for their population size and trade composition.

To calibrate the population and trade shares, we assume, in line with Attinasi et al. (2024), that there are three distinct blocs in the world: Neutral (N), West (W) and East (E). The data source used for calibrating trade shares and GDP shares across the three different blocs is OECD TiVA 2021 Edition, for Year 2018. OECD TiVA contains 67 countries, including a rest-of-the-world aggregate. The allocation mostly relies on the index proposed by Den Besten et al. (2023), based on the history of sanctions, military imports, UN voting, and China's official lending. It ranges between 0 (US-aligned) and 1 (China-aligned). Most of the allocation is mechanical: countries whose index is smaller than 0.333 are assigned to the W bloc, countries whose index is larger than 0.666 are assigned to the E bloc, all the others to the N bloc. A few countries are however manually allocated to a different bloc than the one suggested by the index, to reflect specific patterns (e.g., belonging to EA and historical ties).

Without loss of generality, we fix the population of E at $N^E = 1$. We calibrate the population of W and N to target the GDP share of each bloc in world GDP, $N^W = 4.82427$ targets $GDP^W/GDP^{Wld} = 0.6029$ and $N^N = 0.80597$ targets $GDP^N/GDP^{Wld} = 0.1858$, with an implied GDP share of E as $GDP^E/GDP^{Wld} = 0.2112$.

To calibrate the trade costs, we use the ratio of a bloc's exports to GDP, and the share of exports going to a specific bloc as targets.[16] However, since we assume that the trade of each bloc is balanced in steady state, we cannot target all these shares.[17] Since the fragmentation between W and E is our research objective, we decided to not target the share of N's exports, setting instead $\tau^{NW} = \tau^{NE}$. The implied trade costs are $\tau^{WN} = 1.74475$, $\tau^{WE} = 1.91831$, $\tau^{EN} = 2.09277$, $\tau^{EW} = 2.18067$, and $0.7108.\tau^{NW} = \tau^{NE} = 1.95$. It turns out that trade imbalances in the data are quite small, and thus the share of N's exports going to the West EX^{NW}/EX^N is also close to its data counterpart.

For all other parameters, we follow Ghironi and Melitz (2005) and Cacciatore and Ghironi (2021). We interpret each period as a quarter and set the household discount factor β to 0.99, which targets a 4% annual real interest rate and is the standard choice for quarterly dynamic models. As is standard in the literature, we set the inter-temporal elasticity of the substitution parameter to $\sigma = 2$, the Frisch elasticity parameter to $\vartheta = 2$, and the habit persistence parameter to $\nu = 0.6$. We set the elasticity of substitution between different varieties produced by different firms in the wholesale sector equal to $\theta = 3.8$, based on the estimates from plant-level U.S. manufacturing data in Bernard et al. (2003). Following Cacciatore and Ghironi (2021) we set the elasticity of substitution between bundles in the retail sector $\phi = \theta = 3.8$. We set the parameters of the Pareto distribution to $z_{\text{min}} = 1$ and $k = 3.4$, respectively. This choice satisfies the condition for finite variance of log productivity: $k > \theta - 1$.

We assume that fixed entry and export costs are equal across countries and trading partners. Changing the sunk cost of firm entry f_e only re-scales the mass of firms in an industry. Thus without loss of generality, we can normalize it so that $f_e = 1$. We set the fixed cost of exporting f_x to 19 % of the per-period, amortized flow value of the sunk entry costs, $[1 - \gamma(1 - \delta)]/\,[\gamma(1 - \delta)]f_e$. We set the size of the exogenous firm exit probability to $\delta = 0.025$, to match the level of 10 % job destruction per year in the US. These choices of parameter values are based on Ghironi and Melitz (2005).

[16] Specifically, the targets are the share of W total exports in GDP $EX^W/GDP^W = 0.09$, the share of E total exports in GDP $EX^E/GDP^E = 0.175$, the share of N total exports in GDP $EX^N/GDP^N = 0.238$, the share of exports from W to N in W exports $EX^{WN}/EX^W = 0.5758$ and the share of exports from E to N in total E exports $EX^{EN}/EX^E = 0.3446$.

[17] Balanced trade implies that one of the export-shares is pre-determined and cannot be targeted.

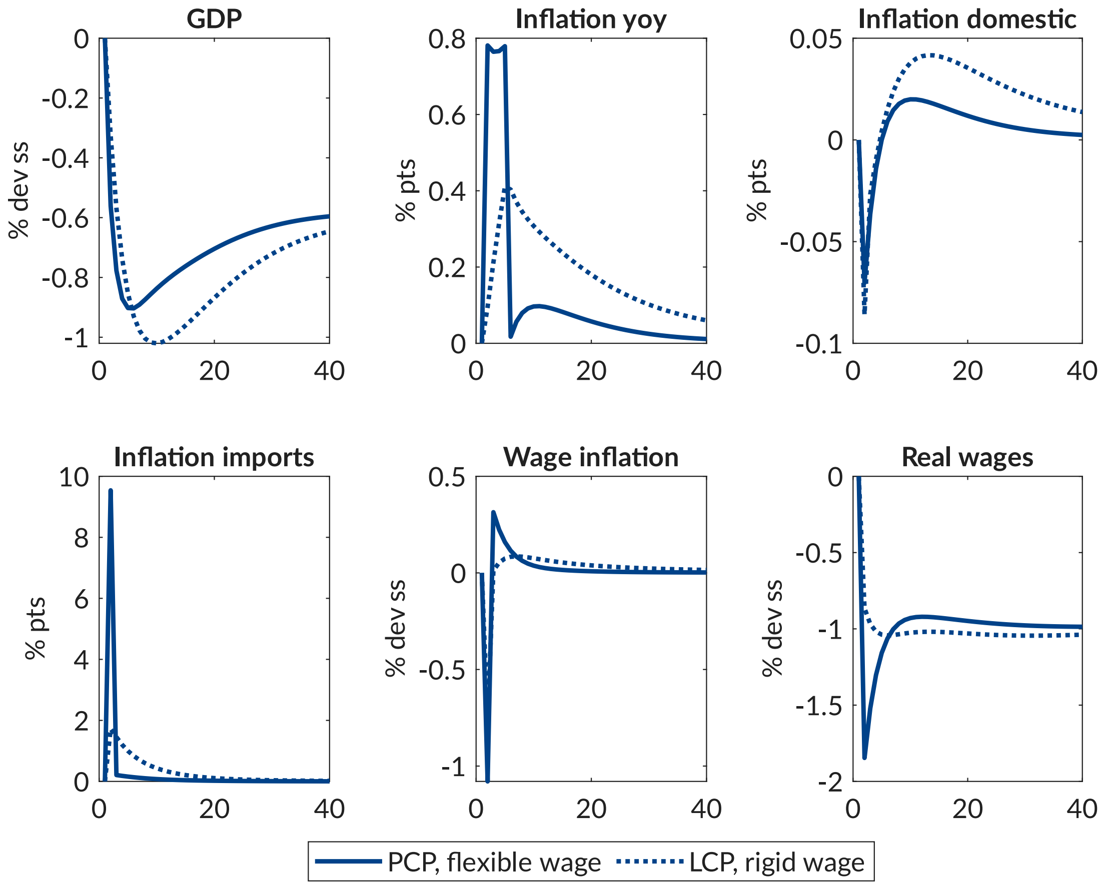
As is standard in the literature, the share of capital in production is set to $\beta_k = 0.33$ and the depreciation rate to $\delta_k = 0.025$ to match a 10% depreciation rate per year. Following Christiano et al. (2005) we set the parameter for investment adjustment costs to $\gamma_k = 4$.

Following Cacciatore and Ghironi (2021), the cost of adjusting prices is set to $\nu = 80$. The cost of adjusting bond holding is $\eta = 0.0025$. For wage rigidity, we set the wage adjustment cost parameter to $\chi^w = 80$ as the price adjustment cost parameter, and the markup parameter to $\phi^w = 11$ to deliver a wage markup of 1.1. As is standard in the literature, the coefficients on the Taylor rule are set to $\kappa_\pi = 1.7$, $\kappa_Y = 0.12$, and $\kappa_i = 0.75$.

C Appendix: Additional charts

Chart C.1

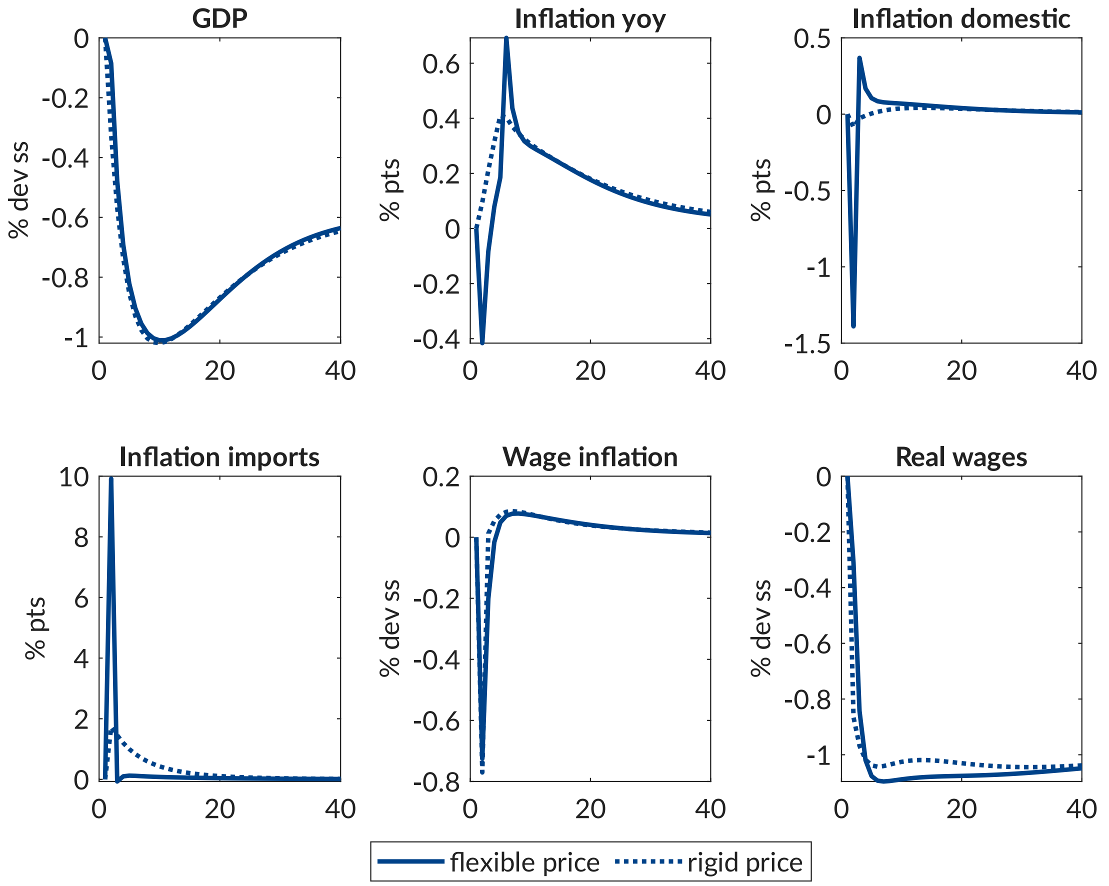
Effects of an increase in trade costs on the Western bloc under flexible wages and PCP



Note: Quarters on the horizontal axis, percent (point) deviations from steady state on the vertical axis.
Source: Authors' calculations.

Chart C.2

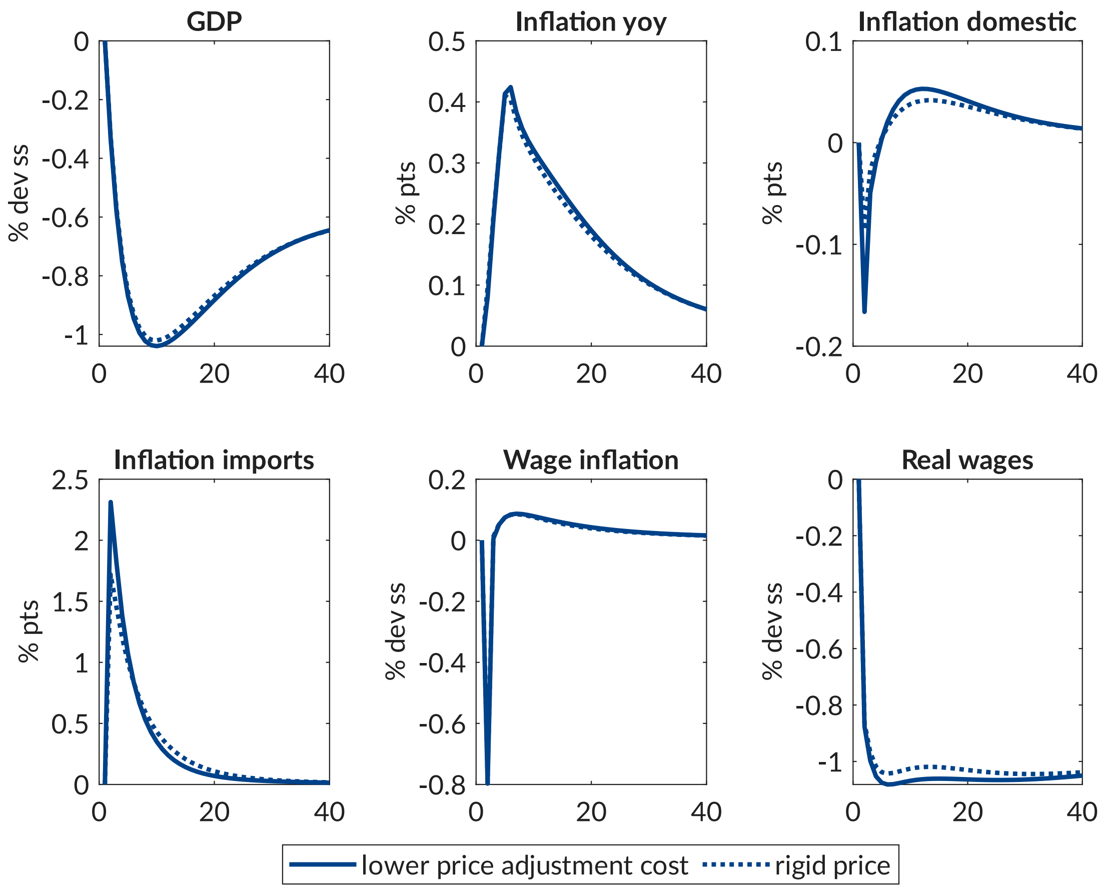
Effects of an increase in trade costs on the Western bloc under flexible prices



Note: Quarters on the horizontal axis, percent (point) deviations from steady state on the vertical axis.
Source: Authors' calculations.

Chart C.3

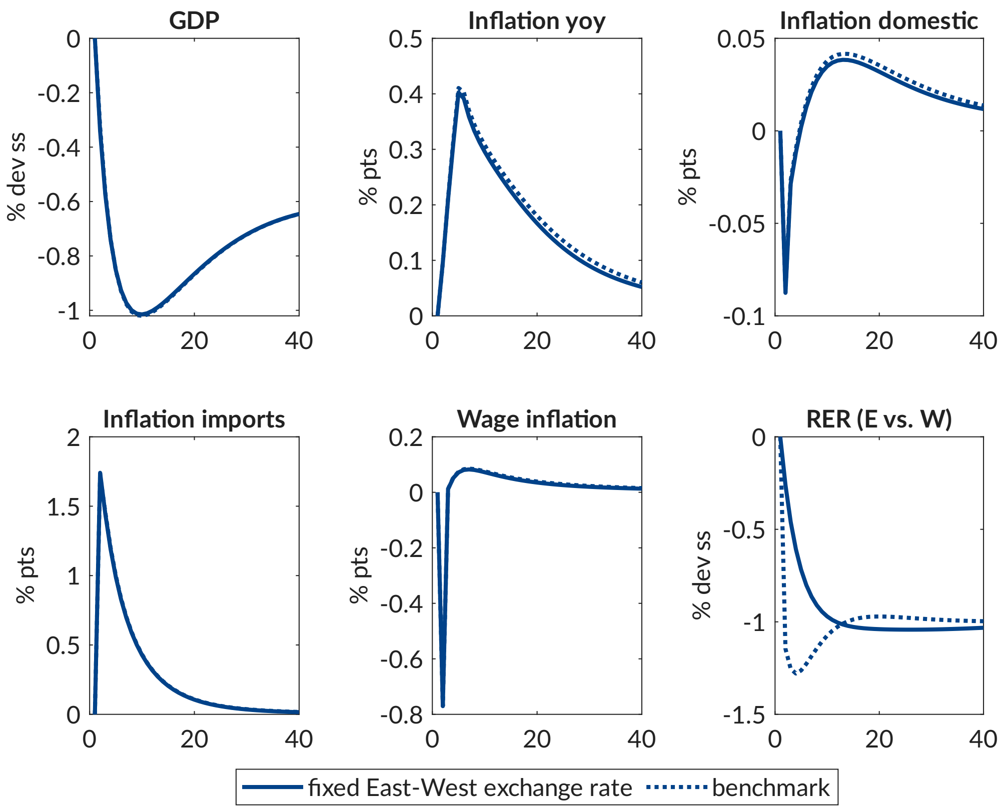
Effects of an increase in trade costs on the Western bloc under halved price adjustment costs



Note: Quarters on the horizontal axis, percent (point) deviations from steady state on the vertical axis.
Source: Authors' calculations.

Chart C.4

Effects of an increase in trade costs on the Western bloc under fixed nominal exchange rate in the Eastern bloc



Note: Quarters on the horizontal axis, percent (point) deviations from steady state on the vertical axis.
Source: Authors' calculations.

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