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BY PETER DIXON[1], JAMES GIESECKE[2], JASON NASSIOS[3] AND MAUREEN RIMMER[4]

We add to the GTAP model a financial module built around an 18-region asset-liability matrix. A financial agent in each region takes account of expected rates of return in allocating the region's financial budget between domestic capital and financial assets in each other region. Using the GTAP model with the financial module in place, we simulate financial decoupling between the U.S. and China. The results show that the U.S. would gain by limiting its financial flows to China, leading to a redirection of finance to the domestic economy. This would stimulate investment in the U.S. with favorable effects on employment, capital stocks, real GDP, wealth, and real wage rates. At the same time investment in China would decline with negative effects on the Chinese economy. Similarly, China would gain by limiting its financial flows to the U.S. and the U.S. would lose. In a tit-for-tat situation in which each country reduces its financial asset holding in the other country by x per cent, the winner would be China. We conduct additional simulations to compare the effects of trade decoupling with those of financial decoupling.

JEL codes: C68, F17, F37, F51.

Keywords: Financial decoupling; U.S.-China economic relations; Trade decoupling; Financial module in GTAP.

[1] Centre of Policy Studies, Victoria University, Melbourne, Victoria, 8001, Australia (peter.dixon@vu.edu.au).
[2] Centre of Policy Studies, Victoria University, Melbourne, Victoria, 8001, Australia (james.giesecke@vu.edu.au).
[3] Centre of Policy Studies, Victoria University, Melbourne, Victoria, 8001, Australia (jason.nassios@vu.edu.au).
[4] Centre of Policy Studies, Victoria University, Melbourne, Victoria, 8001, Australia (Maureen.Bleazby@vu.edu.au).

1. Introduction

Chilling of economic relations between the U.S. and China has led to a stream of GTAP-based papers on the effects of trade restrictions between the two countries, see for example, Tsutsumi (2019), Vanzetti et al. (2020) and Itakura (2020).[5] Trade is not the only economic aspect of the U.S.-China relationship that could be decoupled. There is also an extensive financial relationship with large financial flows in both directions. Over the last couple of years, the possibility of financial decoupling has been discussed actively in policy circles. Commentaries include Lardy and Huang (2020), Scissors (2020) and Takita (2020). However, the discussion of financial decoupling has not been informed by modeling results.

This paper extends the GTAP model so that it can be used not only to analyze policies directed at trade flows, but also policies directed at financial flows. Section 2 sets out the theory and data for a financial module that can be attached to GTAP. With this module attached, we refer to the model as GTAP-Fin. Section 3 describes an application of GTAP-Fin to financial decoupling between the U.S. and China. Section 4 presents results for trade decoupling and compares them to those in section 3 for financial decoupling. Concluding remarks are in section 5. The sensitivity of results to variations in a key parameter is analyzed in the appendix.

In discussions of decoupling, finance and technology transfer are often linked. Here we focus purely on financial flows. Technology transfer can be viewed separately as a matter of how to handle intellectual property issues, patents, and training of foreign students.

2. The financial module: creating GTAP-Fin

2.1. Background

GTAP is the world's most widely applied global CGE model, originally documented in Hertel (1997). Documentation of the current standard version is in Corong et al. (2017). In the standard version, capital moves costlessly between industries within each region and wages either adjust fully to achieve exogenously given levels of employment or wages are exogenous and employment adjusts. In earlier research we added to the standard version industry-specific capital and sticky-wage adjustments, see Dixon et al. (2019). Here, we retain those earlier additions and add to GTAP a financial module. We do this in an 18-region 57-commodity version.

The starting point for our financial module is the Global Trust introduced in GTAP-Dyn by Ianchovichina and McDougall (2012). In their formulation, the

[5] Other global models have also been used to analyze U.S.-China trade decoupling, see for example Robinson and Thierfelder (2019) who use the GLOBE model.

foreign-owned capital of all countries is held in the Global Trust. A country's wealth consists of shares in the Trust plus domestically owned capital within its own borders. There are no direct bilateral financial relationships. Each year a country devotes its savings to buying shares in the Trust and to financing a fraction of its domestic investment (capital creation). The remaining domestic investment is financed by the Trust. The net flow of funds from the Trust is positive for countries with a surplus of domestic investment over savings (current account deficit) and negative for countries with a surplus of saving over investment (current account surplus). The world rate of return on capital adjusts to ensure that the sum across all countries of the net flows of funds from the Trust is zero.

We make three improvements on Ianchovichina and McDougall's Global Trust. First, we introduce bilateral relationships. This is necessary if we are to use the model to understand the effects of policies in which one country discriminates against financial flows from another country. Second, we recognize that financial flows from region *r* to region *s* can "terminate" in region *s* with a claim on *s*'s physical capital, but can also be redirected by *s* to a third region *k*. This recognition is necessary for facilitating the use of available data on the financial assets and liabilities of regions. The data refer to financial claims by residents of one region, on residents of another region; not claims by residents of one region on the physical capital of another region.[6] Third, we use a financial optimizing agent in each region to allocate the region's financial budget across domestic capital and financial assets in other regions. This replaces Ianchovichina and McDougall's cross-entropy approach to determining the allocation of a region's wealth between ownership of domestic capital and shares in the Global Trust.

In extending the Global Trust idea, we use asset-liability matrices and related flow-of-funds matrices. These are central ingredients in Stock-Flow Consistent (SFC) models.[7] SFC models are usually small-scale and focused on macro and monetary phenomena. We are unaware of applications in global CGE modeling.

2.2. Data

Our GTAP financial module is built around asset-liability matrices for the start of 2015 and the end of 2015. Table 1 is the matrix for the start of 2015. The off-diagonal (*s,r*) entry in Table 1 is the value at the start of 2015 of liabilities issued by region *s* that are held by region *r*. For example, the table shows that U.S. financial liabilities (e.g., government bonds or shares in U.S. companies) held by Chinese residents (including Hong Kong) were worth $US3.00 trillion at

[6] We were alerted to this important point by an anonymous referee.

[7] For an authoritative overview of SFC modelling see Nikiforos and Zezza (2017).

Table 1. Assets and liabilities at the start of 2015 ($US trillion)[a]

Asset region / Liability region	1 USA`	2 China	3 Japan	4 Skorea	5 France	6 Germany	7 Brazil	8 India	9 Russia	10 Australia	11 RoAmer	12 RoAsia	13 RoEuro	14 Africa	15 RoW	16 UK	17 Canada	18 Mexico	Total
1 USA	53.85	3.00	2.06	0.28	2.16	2.52	0.21	0.13	0.33	0.42	0.37	2.94	11.17	0.29	0.05	0.43	0.76	0.14	**81.11**
2 China	1.14	40.79	0.66	0.09	0.68	0.80	0.07	0.04	0.10	0.13	0.12	0.93	3.55	0.09	0.02	0.14	0.24	0.05	**49.64**
3 Japan	1.09	0.41	17.73	0.04	0.31	0.37	0.03	0.02	0.05	0.06	0.05	0.43	1.62	0.04	0.01	0.06	0.11	0.02	**22.46**
4 Skorea	0.21	0.08	0.06	5.43	0.06	0.07	0.01	0.00	0.01	0.01	0.01	0.08	0.32	0.01	0.00	0.01	0.02	0.00	**6.41**
5 France	1.90	0.72	0.52	0.07	10.91	0.64	0.05	0.03	0.08	0.11	0.09	0.75	2.83	0.07	0.01	0.11	0.19	0.04	**19.13**
6 Germany	1.81	0.69	0.50	0.07	0.52	15.10	0.05	0.03	0.08	0.10	0.09	0.71	2.70	0.07	0.01	0.10	0.18	0.03	**22.84**
7 Brazil	0.33	0.13	0.09	0.01	0.09	0.11	6.65	0.01	0.01	0.02	0.02	0.13	0.49	0.01	0.00	0.02	0.03	0.01	**8.16**
8 India	0.18	0.07	0.05	0.01	0.05	0.06	0.01	6.24	0.01	0.01	0.01	0.07	0.27	0.01	0.00	0.01	0.02	0.00	**7.08**
9 Russia	0.21	0.08	0.06	0.01	0.06	0.07	0.01	0.00	4.33	0.01	0.01	0.08	0.31	0.01	0.00	0.01	0.02	0.00	**5.28**
10 Australia	0.50	0.19	0.14	0.02	0.15	0.17	0.01	0.01	0.02	4.98	0.02	0.20	0.75	0.02	0.00	0.03	0.05	0.01	**7.28**
11 RoAmer	0.36	0.14	0.10	0.01	0.10	0.12	0.01	0.01	0.02	0.02	7.50	0.14	0.54	0.01	0.00	0.02	0.04	0.01	**9.14**
12 RoAsia	2.20	0.84	0.61	0.08	0.63	0.74	0.06	0.04	0.10	0.12	0.11	22.27	3.29	0.09	0.02	0.13	0.22	0.04	**31.59**
13 RoEuro	9.76	3.72	2.69	0.36	2.81	3.29	0.28	0.16	0.43	0.55	0.48	3.83	32.16	0.38	0.07	0.56	0.99	0.19	**62.70**
14 Africa	0.30	0.12	0.08	0.01	0.09	0.10	0.01	0.01	0.01	0.02	0.01	0.12	0.45	5.96	0.00	0.02	0.03	0.01	**7.36**
15 RoW	0.05	0.02	0.01	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.02	0.08	0.00	0.75	0.00	0.01	0.00	**1.00**
16 UK	0.19	0.07	0.05	0.01	0.06	0.07	0.01	0.00	0.01	0.01	0.01	0.08	0.29	0.01	0.00	10.61	0.02	0.00	**11.50**
17 Canada	0.63	0.24	0.17	0.02	0.18	0.21	0.02	0.01	0.03	0.04	0.03	0.25	0.94	0.02	0.00	0.04	6.85	0.01	**9.69**
18 Mexico	0.25	0.09	0.07	0.01	0.07	0.08	0.01	0.00	0.01	0.01	0.01	0.10	0.37	0.01	0.00	0.01	0.03	4.27	**5.40**
Total	**74.96**	**51.41**	**25.65**	**6.53**	**18.96**	**24.54**	**7.49**	**6.74**	**5.62**	**6.62**	**8.95**	**33.13**	**62.13**	**7.11**	**0.95**	**12.31**	**9.82**	**4.84**	**367.76**

[a] The off-diagonal entries in this matrix form a conventional foreign asset/liability table: entry (s,r) for $r \neq s$ is holdings by r of financial liabilities issued by s. The diagonal entries are values of physical capital in each region. As explained in section 3, the r^{th} column sum is the value of the portfolio managed by the financial agent in r.

the start of 2015. Similarly, Chinese financial liabilities held by U.S. residents were worth $US1.14t.

The *r*th diagonal entry in the table is the value of physical assets located in region *r*. For example, the table shows that at the start of 2015, physical assets in the U.S. were worth $US53.85t. As will be explained in the next subsection, we assume that physical assets in region *r* are financed through *r*'s financial agent but are not necessarily owned by residents of region *r*. Foreign ownership of *r*'s physical capital is part of *r*'s foreign liabilities (the off-diagonal entries in *r*'s row of Table 1).

In Table 1, the difference between the column and row sums for a region is the region's net foreign assets. For the U.S., net foreign assets at the start of 2015 were -$US6.15t (=74.96t – 81.11t). That is, the U.S. had net foreign liabilities of $US6.15t.

Wealth for region *r* can be calculated from Table 1 as the diagonal entry (*r,r*) plus the column-*r* sum less the row-*r* sum, that is the value of *r*'s physical capital plus *r*'s net foreign assets. For example, U.S. wealth at the start of 2015 was $US47.70t made up of physical capital in the U.S. worth $US53.85t plus net foreign assets worth -$US6.15t.

The off-diagonal row sum in Table 1 for region *r* (*r*'s foreign liabilities) and the off-diagonal column sum (*r*'s foreign assets) were derived from IMF data. The diagonal entries (the value of physical capital) were derived from the GTAP database for 2014. The non-diagonal entries in the U.S./China block (north-west corner) were obtained from a variety of U.S. Bureau of Economic Analysis and U.S. Treasury sources, and from China's State Administration of Foreign Assets. The rest of the non-diagonal entries in the table were derived by a modified RAS procedure in which we set the starting point for the regional composition of each country's foreign liabilities to reflect the regional composition of world foreign assets. Similar processes were used to obtain end-of-year data for 2015. Details of the data sources and estimating methods are in Dixon et al. (2020, Appendices 1 and 3).

2.3. Theory

Our objective is to create a theoretical structure in which the components of Table 1 respond dynamically to saving, investment, the current account, and rates of return in each region. Towards this objective we introduce regional financial agents. The agent for region *r* determines the allocation of region *r*'s *end-of-year* financial budget across assets (the r^{th} column in the end-of-year asset-liability matrix) by solving an optimizing problem.

2.3.1 Financial budgets

We define region *r*'s end-of-year financial budget expressed in U.S. dollars, $FB1_r$, as:

$$FB1_r = VK0_r * V_r + FA0_r + SAVE_r + FL1_r - FL0_r \quad (1)$$

In this equation and throughout the paper we use "0" and "1" to denote start- and end-of-year values of stock variables: $VK0_r$ is the start-of-year value in \$U.S. of physical capital in region r. V_r is a valuation factor applying to physical capital in region r. If the price of capital goods in \$U.S. (pcgds in GTAP notation) increases during the year by 1 per cent in region r, then V_r equals 1.01. $FA0_r$ is the start-of-year value in \$U.S. of r's foreign assets. We don't allow for a valuation factor on foreign assets and liabilities. $SAVE_r$ is saving net of depreciation in \$U.S. during the year in r. $FL0_r$ and $FL1_r$ are r's foreign liabilities in \$U.S. at the start- and end-of-year.

Via (1) we assume the financial agent in region r has responsibility for allocating an end of year budget consisting of: the end-of-year value of region r's start-of-year assets supplemented by region r's net savings and by additional finance entrusted to r during the year by foreigners.

Equivalently, r's end-of-year financial budget could be defined as:

$$FB1_r = VK1_r + FA1_r \quad (2)$$

which is r's column sum in the end-of-year version of Table 1. The equivalence is established through the identities

$$SAVE_r = I_r + (FA1_r - FA0_r) - (FL1_r - FL0_r) \quad (3)$$

and

$$VK1_r = VK0_r * V_r + I_r \quad (4)$$

where I_r is investment net of depreciation during the year in region r.

Definition (1) identifies the sources of r's financial budget (end-of-year value of start-of-year financial assets, domestic saving and borrowing from foreigners). Definition (2) identifies the disbursement of r's financial budget (financing of domestic physical capital and acquisition of foreign financial assets).

2.3.2 Financial agent optimizing problem

The optimizing problem that we specify for r's financial agent in year t is to choose $Z1_{s,r}$ to maximize a CES function of the form

$$\left[\sum_s \delta_{s,r} * \left(R_{s,r} * Z1_{s,r}\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \quad (5)$$

subject to

$$\sum_s Z1_{s,r} = FB1_r \quad (6)$$

where $Z1_{s,r}$ is the end-of-year value of *r*'s assets in *s* (the end-of-year value of *r*'s physical capital $VK1_r$, when $s = r$, and the end-of-year value of *r*'s financial assets in s for $r \neq s$); $R_{s,r}$ is the rate of return that *r*'s financial agent expects on assets in *s* (including *r*); and $\delta_{s,r}$ and σ are positive parameters, with $\sigma > 1$.

In optimization problem (5) - (6), *r*'s financial agent treats assets in different regions as imperfect substitutes with the degree of substitutability controlled by the parameter σ (the elasticity of substitution). Via the $\delta_{s,r}$ parameters, (5) – (6) takes account of home bias and other existing bilateral links affecting *r*'s choice of assets. If between years *t-1* and *t*, the expected rate of return on assets in *s* increases relative to those in other regions, then in (5) – (6) each region *r* allocates an increased proportion of its end-of-year financial budget towards assets in *s*.

From (5) – (6) we can derive the end-of-year level of *r*'s assets in *s* as:

$$Z1_{s,r} = FB1_r \left(\frac{{\delta_{s,r}}^{\sigma} * {R_{s,r}}^{\sigma-1}}{\sum_k {\delta_{k,r}}^{\sigma} * {R_{k,r}}^{\sigma-1}} \right) \forall s, r \qquad (7)$$

Standard GTAP determines saving and investment ($SAVE_r$ and I_r) in each region *r*. These are ingredients in $FB1_r$, providing a link from standard GTAP to the determination of *r*'s assets and *s*'s liabilities via (7). We build in another link through the determination of expected rates of returns, the $R_{s,r}$'s.

2.3.3. Expected rates of return

We assume that the rate of return that the financial agent in *r* expects on domestic capital is given by:

$$R_{r,r} = RORE_r \ \forall r \qquad (8)$$

In this equation, $RORE_r$ is the standard GTAP variable for the rate of return expected by capital creators on their investments in region *r*. This is an increasing function of the current rate of return ($RORC_r$ in GTAP notation) reflecting the ratio of the rental value of capital to the creation cost per unit ($PCGDS_r$), and a decreasing function of the rate of growth of capital with extra risk being associated with fast growth.

Consistent with our idea that when region *r* sends funds to region *s*, $s \neq r$, it does so through the financial agent in region *s*, we assume that the rate of return that *r* expects on these funds reflects the expected rate of return on the portfolio managed by the agent in *s*. We assume that:

$$R_{s,r} = \left[R_{s,s} * S_{s,s} + \sum_{k \neq s} R_{k,s} * S_{k,s} \right] * T_{s,r} \ \forall s, r, s \neq r \qquad (9)$$

where $S_{k,s}$ is the share of agent s's portfolio accounted for by assets managed by the financial agent in k, that is

$$S_{k,s} = \frac{Z0_{k,s}}{\sum_q Z0_{q,s}} \ \forall k, s \ (this\ includes\ k = s) \tag{10}$$

$T_{s,r}$ is a shift variable that can be used in simulating the effects of financial decoupling. For example, in the simulations reported in section 3, we introduce reductions in $T_{China,US}$ and $T_{US,China}$. These cause reductions in the rates of return that the U.S. financial agent expects on funds committed to China and that the Chinese financial agent expects on funds committed to the U.S. Then via (7) the U.S. financial agent redirects funds away from China and the Chinese financial agent redirects funds away from the U.S.

Our model doesn't distinguish between FDI and portfolio investment. Residents of region *r* buy a bundle of assets located primarily in region *s* when they entrust money to the financial agent in region *s*. Equations (9) and (10) represent the rate of return expected by residents of region *r* averaged across their FDI and portfolio investments in *s*.

2.3.4 Distribution across regions of capital income

We define income per dollar of assets managed by the financial agent for region *s* in the current year by:

$$CR_s = \frac{NR_s + \sum_{r \neq s} Z0_{r,s} * CR_r}{\sum_r Z0_{r,s}} \ \forall s \tag{11}$$

where NR_s is the rental on physical capital in *s*, net of depreciation. This is a standard GTAP variable.

Then, receipts for region *r* on its foreign assets and payments on its foreign liabilities are given by:

$$RFA_r = \sum_{s \neq r} CR_s * Z0_{s,r} \ \forall r \tag{12}$$

$$PFL_r = \sum_{s \neq r} CR_r * Z0_{r,s} \ \forall r \tag{13}$$

We include the difference ($RFA_r - PFL_r$) between these receipt and payment variables in *r*'s net national product ($INCOME_r$ in GTAP notation).

2.3.5 How does GTAP-Fin work: how does it produce a solution for year t?

Assume that we have an asset–liability table for the start of year t, that is we know $Z0_{s,r}$ for all s and r. Assume that we have set the values for the parameters $\delta_{s,r}$ and σ in (7).

Conceptually, we can envisage an iterative process. Adopt initial guesses for $RORE_s$ for all s. Then for each region s, we can use the investment and capital accumulation equations in standard GTAP to obtain a demand-side estimate of investment and end-of-year capital stock. With the $T_{s,r}$'s exogenous, (8) and (9) give us estimates of the rates of return expected by financial agents, $R_{s,r}$. Provided we can make reasonable guesses of the financial budgets of each region, $FB1_r$ for all r,[8] we can use (7) to obtain an estimate of the end-of-year asset-liability matrix, ($Z1_{s,r}$). The diagonal components of this matrix are supply-side estimates of the value of end-of-year capital stock for each region. If the demand-side estimate for region s is greater than the supply-side estimate, this means that capital creators in region s are demanding more investment funds than financial agents want to supply to region s. In an iterative process we move towards eliminating this disequilibrium by making an upward adjustment in the assumed value for $RORE_s$. We can anticipate that a higher value for $RORE_s$ will decrease investment demand in s: less investment projects can achieve the higher expected rate of return. At the same time, we can anticipate that the upward adjustment in $RORE_s$ will increase the $R_{s,r}$'s for all r and consequently the value of funds supplied to s.

While describing an iterative process is instructive and gives us confidence that our model is complete, it is not necessary for computation. All of the equations in the financial module can be included in GTAP and solved simultaneously.

2.4. Implementation

This subsection sets out the equations for the financial module in percentage-change form suitable for use in GEMPACK.[9] We define the coefficients in these equations and discuss their evaluation. While this material will be useful to readers who want to implement a financial module, it can be skipped by readers whose interest is confined to theory and results.

The financial module consists of equations (1), (7), (8), (9), (10), (11), (12) and (13). In percentage-change form, these equations can be written as:

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[8] In the iterative process that we are describing here, guesses of $FB1_r$ for all r could be revised at each step using (1).

[9] See Horridge et al. (2018).

$$FB1_r * fb1_r = Z0_{r,r} * V_r * \left(z0_{r,r} + v_r\right) + FA0_r * fa0_r \\ +SAVE_r * save_r + FL1_r * fl1_r - FL0_r * fl0_r \ \forall r \tag{1a}$$

$$z1_{s,r} = fb1_r + (\sigma - 1) * \left(r_{s,r} - \sum_j SH1_{j,r} * r_{j,r} \right) \forall s, r \tag{7a}$$

$$r_{r,r} = rore_r \ \forall r \tag{8a}$$

$$\frac{R_{s,r}}{T_{s,r}} * \left(r_{s,r} - t_{s,r}\right) = \sum_k R_{k,s} * S_{k,s} * (r_{k,s} + s_{k,s}) \ \forall s, r; s \neq r \tag{9a}$$

$$s_{k,s} = z0_{k,s} - fb0_s \ \forall \ k, s \tag{10a}$$

$$CR_s * FB0_s * (cr_s + fb0_s) \\ = NR_s * nr_s + \sum_{r \neq s} Z0_{r,s} * CR_r * \left(z0_{r,s} + cr_r\right) \forall s \tag{11a}$$

$$RFA_r * rfa_r = \sum_{s \neq r} CR_s * Z0_{s,r} * \left(cr_s + z0_{s,r}\right) \forall r \tag{12a}$$

$$PFL_r * pfl_r = \sum_{s \neq r} CR_r * Z0_{r,s} * \left(cr_r + z0_{r,s}\right) \forall r \tag{13a}$$

where the lowercase symbols, $fb1_r$, $z0_{s,r}$, etc, denote percentage changes between years *t-1* and *t* in the variables represented by the corresponding uppercase symbols.

Nearly all of coefficients appearing in these equations were defined in the discussion of the equations in subsection 2.3. The only new coefficients are $FB0_s$ and $SH1_{j,r}$ appearing in (11a) and (7a). $FB0_r$ is the start of year value of *r*'s financial budget (the *r*th column sum of the start-of-year asset-liability table), and $SH1_{j,r}$ is the share of *r*'s end-of-year financial budget that is held as assets in *j*. This is given by

$$SH1_{j,r} = \frac{Z1_{j,r}}{FB1_r} \tag{14}$$

To include these percentage-change equations in a GEMPACK version of GTAP, we need a database that allows us to evaluate all of the coefficients for a base year, 2015. As described in subsection 2.2, we compiled start- and end-of-year asset-liability tables for 2015. These enabled us to evaluate $FB0_r$, $FB1_r$, $Z0_{r,s}$, $FA0_r$, $FL1_r$, $FL0_r$, $SH1_{j,r}$ and $S_{k,s}$. The coefficients $SAVE_r$ and NR_s were directly available from the 2014 GTAP database (Aguiar et. al. 2019) that we updated to 2015. We computed 2015 values for CR_s by solving the system of simultaneous equations (11). With the CR's in place we used (12) and (13) to evaluate RFA_r and PFL_r. We assumed that $T_{s,r}$ in the base year was one for all *s*, *r* and that expected rates of return ($RORE_r$) were uniform across regions. Without further loss of generality, we assumed that the base-year values for the rates of return, $R_{k,s}$, expected by the financial agents were uniformly one. Consistent with the rate of inflation in U.S.-dollar prices assumed in our baseline, we set the database values of V_r at 1.02 for all r. That left only the value for the substitution elasticity in the CES objective function, σ, to be assigned.

In the simulations in section 3, we set σ at 3. We consider this to be a "middle value". A much lower value would be inconsistent with the observation of large sort-run international financial flows. A much higher value would be inconsistent with observed relative stability of the column structure of asset-liability matrices. An analysis of the sensitivity of principal results from section 3 to variations in our chosen value is in the appendix.

With coefficients evaluated for the base year, 2015, and parameter values assigned, we can compute a GTAP-Fin solution for 2016. This reveals end-of-year values for assets and liabilities, which can be used as start-of-year values for 2017. In this way, a dynamic solution for multiple years can be obtained.

3. Financial decoupling between the U.S. and China

3.1. Setting up the simulations

In this section we report results from three simulations with GTAP-Fin. A simulation consists of two runs: a baseline or business-as-usual run, and a perturbation run. We adopt the same baseline run in all three simulations. This is generated under bland (no-Covid) assumptions concerning GDP and employment growth in each region for the period 2015 to 2025. In the perturbation runs, we introduce exogenous changes in U.S. asset holdings in China and Chinese asset holdings in the U.S. In terms of the asset-liability table, we shock the entries in the China row/USA column and in the USA row/China column. The effects of these shocks are calculated as differences between results in the perturbation run and those in the baseline run.

In the first simulation, the perturbation shock is a 50 per cent reduction in U.S. assets held in China phased in over three years, 2016, 2017 and 2018. In the second simulation, the perturbation shock is a 50 per cent reduction in Chinese assets held in the U.S., again phased in over these three years. The third simulation combines the shocks from the first two simulations.

The components of the asset-liability table are naturally endogenous. Thus, to shock the China-US and US-China entries we must change the closure so that these entries become exogenous. We do this by endogenizing T-variables in (9). In the first simulation we endogenize $T_{China,US}$. In the second simulation, we endogenize $T_{US,China}$, and in the third simulation we endogenize both. The endogenous outcomes for these T-variables can be thought of as tax or other policies designed to inhibit the holding of Chinese liabilities by U.S. residents and vice versa.

While the computations were performed with the 18-region model, we report results for three regions: U.S., China and the other 16 regions aggregated as Rest of world (RoW). This keeps the presentation manageable, but it also seems reasonable in view of the data input to the model. The effects on a third country, say India, of a reduction in U.S. assets held in China depends on U.S. and Chinese bilateral financial positions with India. Table 1 presents a plausible guess of the U.S.-India and China-India positions, but not hard data. In these circumstances we can't be confident of identifying differences in the effects on India from those on other third countries. On the other hand, at the 3-region level (shown in Table 2) all of the entries are informed by hard data.

Table 2. Assets & liabilities at the start of 2015 ($USt): 3-region version of Table 1

	USA	China	RoW	Total
USA	53.85	3.00	24.26	81.11
China	1.14	40.79	7.70	49.64
RoW	19.97	7.62	161.74	189.33
Total	74.96	51.42	193.70	320.08

3.2. Results for asset and liability values

Table 3 shows how the evolution of the components of Table 2 are affected by decoupling in the three simulations. It gives results for end-of-year asset and liability values in the perturbation runs expressed as percentage deviations from their baseline values.

3.2.1 Asset and liability values in simulation 1

In simulation 1, we phase in the 50 per cent reduction in U.S. asset holdings in China in three equal percentage installments: 20.63 per cent reduction in 2016 [see the (China,USA) entry in the 2016 panel for simulation 1 in Table 3]; a further 20.63 per cent reduction in 2017 giving a cumulative -37.00 per cent deviation [see the (China,USA) entry in the 2017 panel for simulation 1]; and a final 20.63 per cent reduction in 2018 giving a cumulative -50.00 per cent deviation [see the (China,USA) entry in the 2018 panel for simulation 1]. The -50 per cent deviation is maintained to the end of the simulation [see the (China,USA) entry in the 2025 panel for simulation 1].

Simulation 1 shows that an exogenous reduction in U.S. assets in China causes a redirection of U.S. asset holdings (portfolio of the U.S. financial agent) towards domestic and RoW assets. By end-2025, the value U.S. holding of domestic assets (value of physical capital) is 0.30 per cent above baseline and U.S. holding of RoW assets is 0.86 per cent above baseline. The increase in U.S. physical capital comes about because redirection of U.S. funding towards domestic assets allows additional investment projects (projects with lower expected rates of return than in the baseline) to be undertaken. As will be discussed in subsection 3.3.1, additional investment has favorable macroeconomic effects for the U.S., generating extra income and saving, and thus extra wealth (0.14 per cent by end 2025).

For China, the reduction in financial inflow from the U.S. reduces Chinese ability to purchase foreign assets leading to negative deviations in Chinese assets in the both the U.S. and RoW (-2.83 per cent and -1.77 per cent) in 2025. Capital in China is reduced (a deviation of -0.43 per cent in 2025). The redirection of U.S. funding causes elimination of some investment projects in China. The overall wealth effect for China in the long run is negative (-0.17 per cent in 2025). This reflects unfavorable macro effects for China, to be discussed in subsection 3.3.1.

The asset portfolio for RoW is redirected away from the U.S. towards China (a long-run reduction in RoW's holding of U.S. assets of 1.07 per cent, and a long-run increase in its holdings of Chinese assets of 0.97 per cent). This redirection of funds by RoW reflects higher expected rates of return in China (associated with reduced availability of U.S. funding for Chinese investment projects), and lower expected rates of return in the U.S. (associated with increased availability of U.S. funding for U.S. investment projects). There is a long-run positive effect on RoW capital (a deviation of 0.03 per cent). The reduction in the supply of funds from China to RoW is slightly outweighed by the increase in supply from the U.S., allowing a reduction in expected rates of return required for RoW investment projects to be funded. The overall effect on RoW wealth in 2025 is a small positive, 0.01 per cent.

The asset-liability results for simulation 1 in 2018 are quite similar to those in 2025, implying that most of the effects take place within the implementation period of the shocks, 2016-18. However, U.S. capital continues to adjust beyond 2018 (from a deviation of 0.26 per cent in 2018 to a deviation of 0.30 per cent in 2025). This reflects lags built into GTAP's investment-capital accumulation specification. But what about capital in China? In the early years the downward adjustment overshoots the long-run result (a deviation of -0.57 per cent in 2018 recovering to a deviation of -0.43 per cent in 2025). This reflects a recovery in Chinese employment which is initially reduced below baseline by the withdrawal of U.S. finance (see subsection 3.3.1).

3.2.2. Asset and liability values in simulation 2

The results from simulation 2 in Table 3 can be understood in *qualitative* terms by reworking the commentary from subsection 3.2.1 with China and U.S. interchanged. Redirection of Chinese assets away from the U.S. increases Chinese holding of RoW assets (a deviation of 7.68 per cent in 2025) and increases the supply of Chinese funds to domestic investment (a deviation of 1.81 per cent in Chinese capital in 2025). The increase in investment and capital has favorable macroeconomic effects for China generating increased wealth (a deviation of 0.62 per cent in 2025). For the U.S., China's withdrawal of funds causes reductions in

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Table 3. Effects of financial decoupling by U.S. and China on values of assets/liabilities, wealth, and capital: end-of-year percentage deviations from baseline[a]

	2016			2017			2018				2025		
Asset Region	USA	China	RoW	USA	China	RoW	USA	China	RoW		USA	China	RoW
Simulation 1. U.S. cuts assets held in China by 50%													
Liability region													
USA	0.09	-1.64	-0.46	0.18	-2.72	-0.77	0.26	-3.43	-0.98	…	0.30	-2.83	-1.07
China	-20.63	-0.26	0.71	-37.00	-0.45	1.17	-50.00	-0.57	1.46	…	-50.00	-0.43	0.97
RoW	0.26	-1.20	0.02	0.54	-1.99	0.02	0.79	-2.51	0.03	…	0.86	-1.77	0.03
Wealth	*0.08*	*-0.21*	*0.02*	*0.15*	*-0.33*	*0.02*	*0.19*	*-0.38*	*0.02*	…	*0.14*	*-0.17*	*0.01*
Simulation 2. China cuts assets held in the U.S. by 50%													
Liability region													
USA	-0.43	-20.63	0.91	-0.87	-37.00	1.72	-1.25	-50.00	2.44	…	-1.63	-50.00	3.15
China	-5.18	0.83	-3.49	-8.85	1.53	-5.78	-11.46	2.06	-7.25	…	-11.56	1.81	-6.17
RoW	-1.79	3.53	-0.02	-3.29	6.52	-0.02	-4.56	8.92	-0.03	…	-5.87	7.68	-0.10
Wealth	*-0.39*	*0.66*	*-0.01*	*-0.73*	*1.11*	*0.00*	*-0.96*	*1.38*	*0.00*	…	*-0.72*	*0.62*	*0.01*
Simulation 3. U.S. cuts assets held in China by 50% & China cuts assets held in the U.S. by 50%													
Liability region													
USA	-0.34	-20.63	0.50	-0.69	-37.00	1.01	-0.98	-50.00	1.51	…	-1.33	-50.00	2.15
China	-20.63	0.58	-2.77	-37.00	1.09	-4.64	-50.00	1.51	-5.89	…	-50.00	1.40	-5.24
RoW	-1.48	2.37	0.00	-2.71	4.52	0.00	-3.73	6.34	-0.01	…	-4.98	5.89	-0.07
Wealth	*-0.31*	*0.46*	*0.01*	*-0.58*	*0.80*	*0.02*	*-0.76*	*1.01*	*0.02*	…	*-0.58*	*0.47*	*0.01*

[a] Shaded entries are exogenous

domestic capital and foreign assets both in China and RoW. U.S. wealth is adversely affected (a deviation of -0.72 per cent in 2025).

Quantitatively, the results in simulation 2 are larger than the corresponding results in simulation 1. The percentage increases in wealth and capital in 2025 for China in simulation 2 are larger than those for the U.S. in simulation 1 (deviations of 0.62 and 1.81 per cent compared with 0.14 and 0.30 per cent). Similarly, the percentage reductions in wealth and capital in 2025 for the U.S. in simulation 2 are greater than those for China in simulation 1 (deviations of -0.72 and -1.63 per cent compared with -0.17 and -0.43 per cent).

Chinese holdings of assets in the U.S. at the start of 2015 were worth 2.6 times U.S. holdings of assets in China ($US3.00t compared $US1.14t, see Table 2). Consequently, we can think of the shock in simulation 2 as being 2.6 times larger than the shock in simulation 1. However, this doesn't explain all of the difference in the scale of the effects in simulation 2 relative to simulation 1. The percentage wealth and capital effects in 2025 for China in simulation 2 are 4.4 and 6.0 times larger than those for the U.S. in simulation 1. We return to this problem in subsection 3.3.3.

3.2.3. Asset and liability values in simulation 3

The results from simulation 3 in Table 3 are approximately an addition of the results from simulations 1 and 2. For example, the deviation in simulation 3 in U.S. capital in 2025 is -1.33 per cent, approximately the sum of the deviations in simulations 1 and 2 (0.30 – 1.63). Thus, simulation 3 doesn't require separate explanation from simulations 1 and 2.

Apart from non-linearities in the model, there is one technical issue that prevents the add-up from being exact. Looking at the China-USA entries in the 2025 results, we see that the add-up cannot apply. In simulations 1 and 3, a shock of -50 per cent is imposed. In simulation 2, the China-USA entry moves endogenously by -11.56 per cent.

3.3. Macro results

Figures 1, 2, and 3 show results from our three simulations for real GDP, employment, and physical capital. In looking at these results, it is worth noting that in Table 3 the deviation results for capital refer to values of physical capital stocks. In this subsection we are concerned mainly with quantities of physical capital stocks. The movements in values and quantities are similar because we assume no change in the world price level or nominal exchange rates. However, prices of capital can change relative to other prices so that movements in values and quantities of capital are not identical.

3.3.1. Macro results in simulation 1

Reduction of U.S. assets in China redirects U.S. funding towards domestic assets. This reduces the expected rate of return required for an investment project in the U.S. to receive funding. Thus, there is a boost to U.S. investment and, as illustrated in Figure 1C, the U.S. capital stock moves above baseline. Under the sticky-wage-adjustment mechanism built into GTAP-Fin, extra capital in the U.S. temporarily boosts U.S. employment (Figure 1B). Eventually wage rates adjust, returning employment to baseline, but leaving the benefit of a permanent increase in real wage rates. Both the capital and employment effects contribute to an increase in real GDP (Figure 1A).

Extra employment in the U.S. generates extra income and saving. Extra saving accumulates into extra wealth (a deviation of 0.14 per cent in 2025, Table 3). An effect captured by GTAP-Fin, but not shown here, that also contributes to the growth in U.S. saving and wealth in simulation 1 is an improvement in the U.S. terms of trade. Greater capital creation in the U.S. strengthens the real exchange rate and increases the price of exports relative to the price of imports.

The results for China in Figure 1 are qualitatively the opposite of those for the U.S. The withdrawal of U.S. funding increases required rates of return for investment in China. This reduces capital in China (Figure 1C), temporarily reduces employment (Figure 1B), reduces real GDP (Figure 1A), and reduces wealth.

For RoW, the effects are small but positive. As we saw earlier, in simulation 1 RoW gains investible funds from the U.S. and loses funds from China, but the gain outweighs the loss. RoW benefits from the redistribution of investible funds away from China back to the U.S. This is because the U.S. invests about 26 per cent of its portfolio in RoW ($US19.97t out of $US74.96t, Table 2) while China invests only about 15 per cent of its portfolio in RoW ($US7.62t out of $US51.42t, Table 2).

3.3.2. Macro results in simulation 2

As in our discussion of Table 3, we can understand the macro results for simulation 2 in qualitative terms by reworking the commentary for simulation 1 with China and the U.S. interchanged. In simulation 2, the GDP, employment, capital, and wealth effects for China are favorable (Figure 2 and Table 3), while for the U.S. they are unfavorable. For RoW, the effects are slightly unfavorable.

In subsection 3.2.2, we explained that the shock in simulation 2 can be thought of as being 2.6 times larger than that in simulation 1. But we saw that the factor of 2.6 didn't apply to wealth and capital: the percentage wealth and value-of-capital effects in 2025 for China in simulation 2 are 4.4 and 6.0 times larger than those for the U.S. in simulation 1. Now we see a similar phenomenon for the GDP and quantity-of-capital results. The percentage GDP and capital quantity effects in 2025 for China in simulation 2 are 8.7 and 7.7 times larger than those for the U.S. in simulation 1 (0.52 compared with 0.06 and 1.55 compared with 0.20, Figures 2 and 1).

In simulation 1, $0.57t (50 per cent of U.S. assets in China, Table 2) is returned to the U.S. financial agent for reinvestment. Potentially, this could finance a long-run increase in U.S. capital of about 1.06 per cent (= 100*0.57/53.85). Similarly in simulation 2, $1.5t (50 per cent of Chinese assets in the U.S., Table 2) is returned to the Chinese financial agent for reinvestment. Potentially, this could finance a long-run increase in Chinese capital of about 3.68 per cent (= 100*1.50/40.79). On this basis we might expect the eventual effects on capital and GDP in China in simulation 2 to be about 3.47 times those in the U.S. in simulation 1 (3.47 = 3.68/1.06).

This first back-of-the-envelope explanation can be refined by recognizing that RoW absorbs 27.05 per cent [= 100*19.97/(19.97+53.85)] of U.S. non-Chinese assets. Taking this into account, we can recalculate the long-run potential impact on U.S. capital of the return of funds from China in simulation 1 as 0.77 per cent [=(1-0.2705)*1.06]. For China, RoW absorbs 15.74 per cent [= 100*7.62/(7.62+40.79)] of non-US assets, suggesting a recalculated long-run potential impact on Chinese capital of the return of funds from the U.S. in simulation 2 of 3.10 per cent [= (1-0.1574)*3.68]. On this basis we could now understand that the eventual effects on capital and GDP in China in simulation 2 might be about 4.03 times those in the U.S. (4.03 = 3.10/0.77).

So what are we missing? The exogenous restriction of U.S. assets in China in simulation 1 allows a sustained reduction in expected rates of return on capital in the U.S. as the U.S. devotes some of the returned funds to capital expansion. A similar phenomenon occurs for China in simulation 2. However, the sustained reduction in the expected rate of return on China's capital in simulation 2 is about 7 times greater than that for the U.S. in simulation 1. This explains why the percentage expansion of China's capital in simulation 2 is about 7 times greater than that for the U.S. in simulation 1. But what explains the sharp reduction in the expected rate of return for China in simulation 2 relative to that for the U.S. in simulation 1, beyond the factor of 4.03 suggested by our refined back-of-the-envelope calculation?

The answer is the greater financial openness of the U.S. compared with China. As can be seen from Table 2, 30 per cent of U.S. financial liabilities are financed by RoW (24.26 out of 81.11) and the U.S. places 27 per cent of its financial assets in RoW (19.97 out of 74.96). The corresponding percentages for China are 16 and 15 (7.70 out of 49.64 and 7.62 out of 51.42). Expansions in U.S. capital in simulation 1 and Chinese capital in simulation 2 and associated reductions in expected rates of return are limited by increased capital outflow and reduced capital inflow. With greater openness, these limiting effects on capital expansion operate much more strongly for the U.S. than for China.

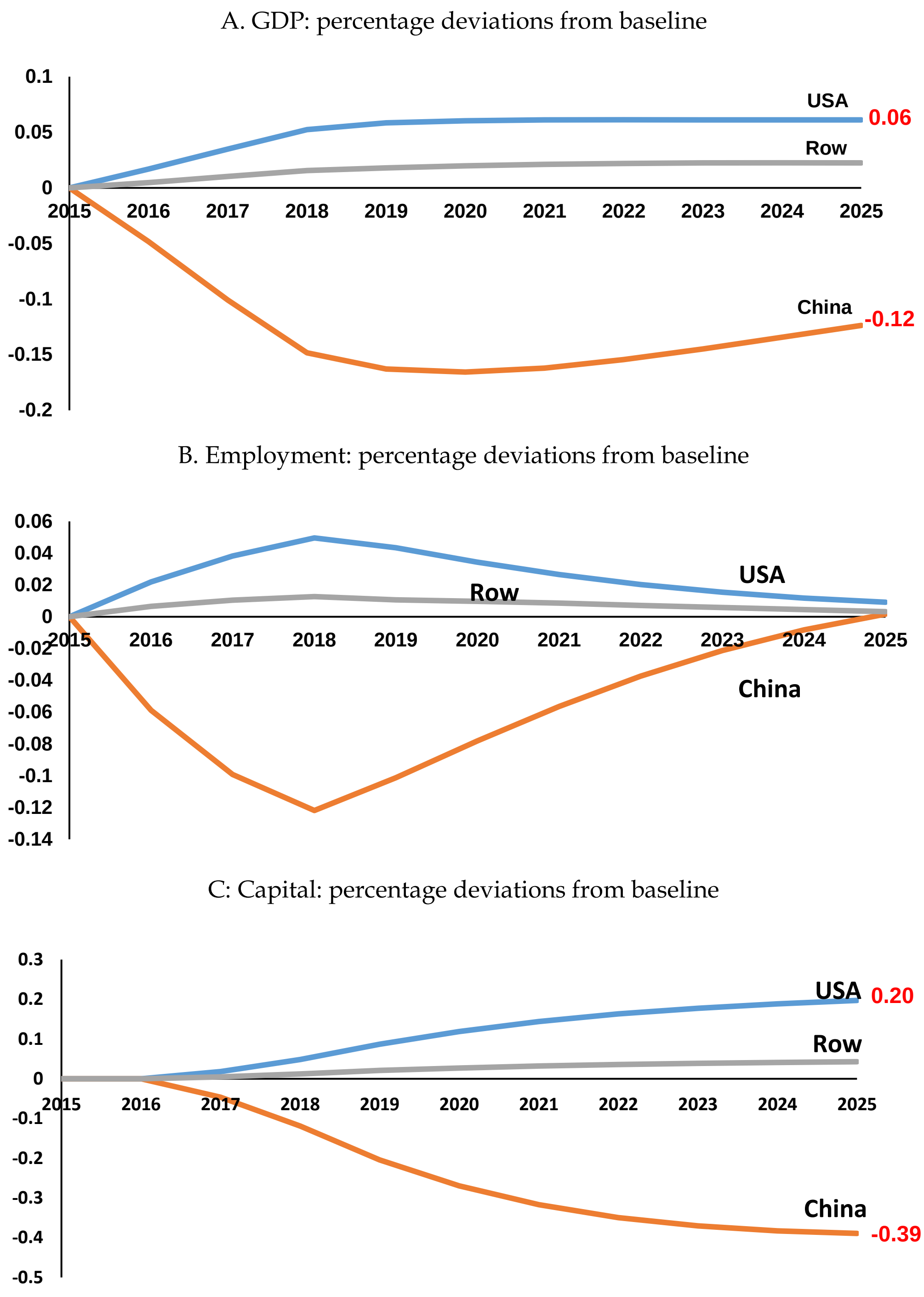
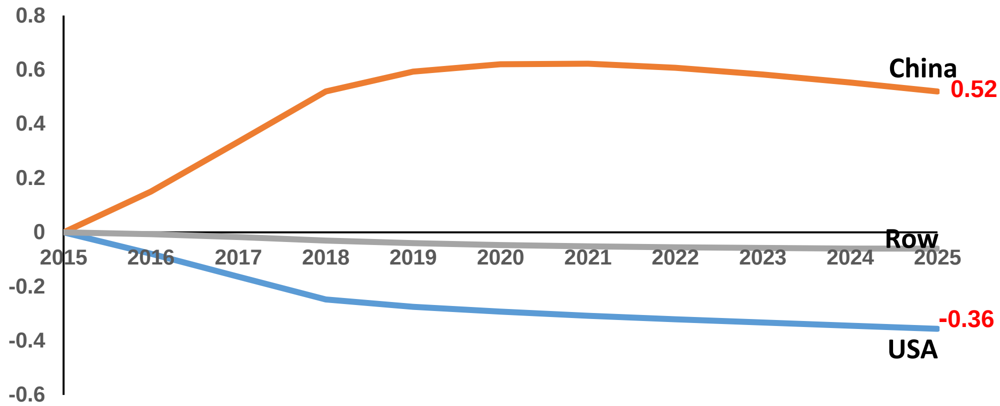
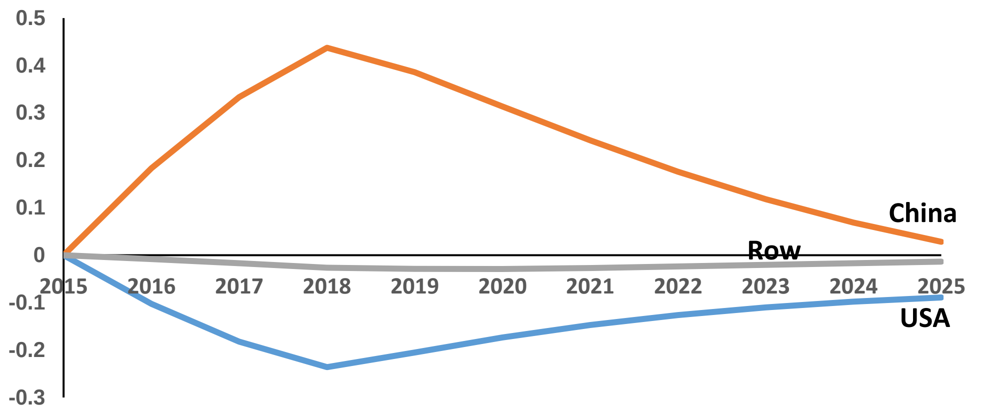


Figure 1. Simulation 1: U.S reduces its financial assets in China by 50% over 3 years

A. GDP: percentage deviations from baseline



B. Employment: percentage deviations from baseline



C: Capital: percentage deviations from baseline

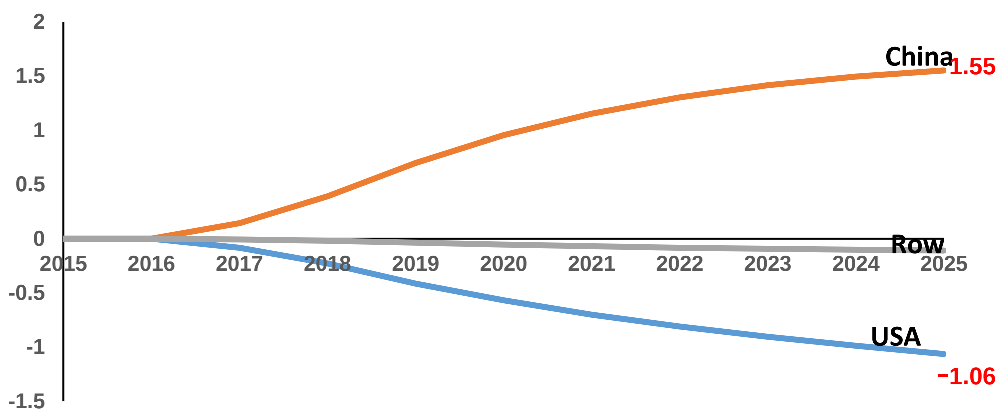
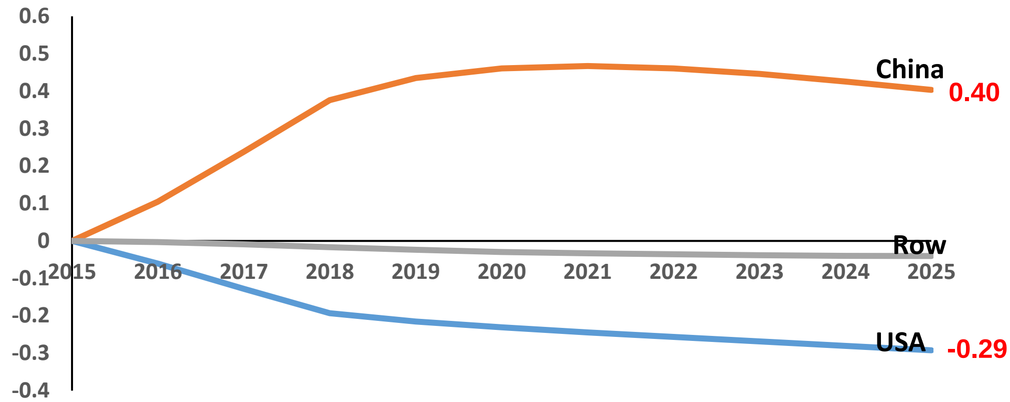
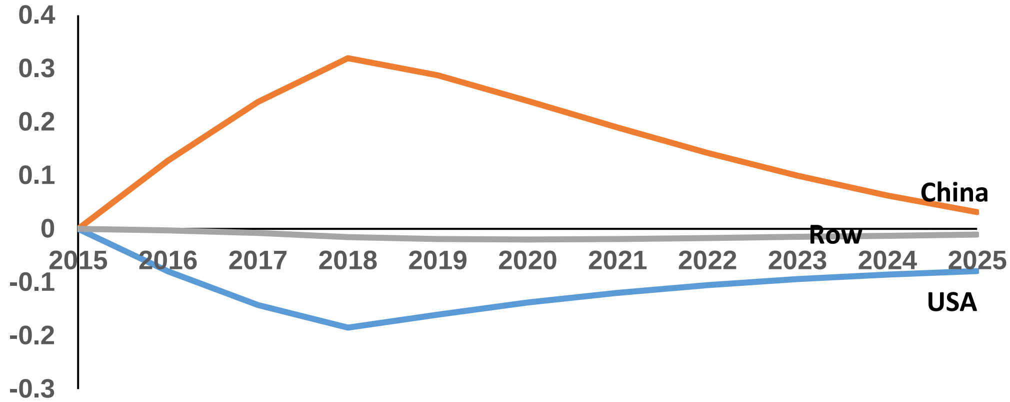


Figure 2. Simulation 2: China reduces its financial assets in the U.S. by 50% over 3 years

A. GDP: percentage deviations from baseline



B. Employment: percentage deviations from baseline



C: Capital: percentage deviations from baseline

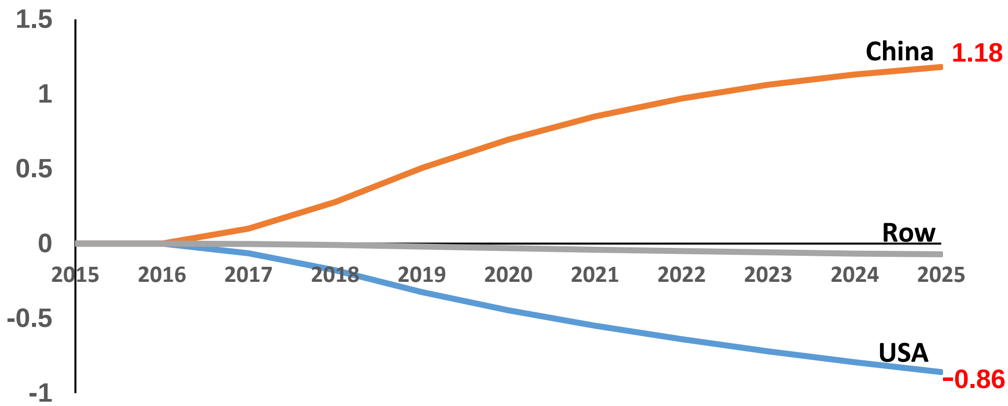


Figure 3. Simulation 3: U.S reduces its financial assets in China by 50% & China reduces its financial assets in the U.S. by 50% over 3 years

3.3.3. Macro results in simulation 3

The macro results for simulation 3 are approximately the sum of those from simulations 1 and 2. Because simulation 2, which favors China, has bigger effects than simulation 1, which favors the U.S., we would expect the combined simulation to be favorable to China. This is shown in Figure 3 where the GDP, employment and capital deviations for China are positive and those for the U.S. are negative.

4. Trade decoupling between the U.S. and China: how does it compare with financial decoupling?

In this section we compare GDP results from three trade-decoupling simulations with those from section 3 on financial decoupling. Paralleling the approach in section 3, in the first trade-decoupling simulation we phase in a 50 per cent reduction over three years in all U.S. imports from China. To achieve the required reductions in imports, we use an endogenous uniform tariff imposed by the U.S. on China. In the second trade-decoupling simulation we phase in a 50 per cent reduction in all Chinese imports from the U.S. using an endogenous uniform Chinese tariff against the U.S. In the third trade-decoupling simulation we phase in 50 per cent reductions in all U.S. imports from China and all Chinese imports from the U.S., using endogenous U.S. and Chinese tariffs.

4.1. Overview of trade-decoupling results

The GDP results from the three trade-decoupling simulations are shown in Figure 4.

The U.S. tariff against China reduces U.S. GDP in both the short run and long run [Figure 4(i)]. Detailed results not presented here show that the negative short-run effect is generated mainly by a reduction in employment. Tariffs are an indirect tax, reducing the real wage rate at which any given level of employment can be sustained. Under the sticky real-wage assumption adopted in GTAP-Fin, when a tariff is imposed employment falls until wages can adjust. The negative long-run effect for the U.S. is generated mainly by a reduction in capital. Replacement of imports from China stimulates labor-intensive production in the U.S. resulting in a long-run reduction in the capital/labor ratio.

The sticky-wage assumption is also the main explanation for the short-run reduction in China's GDP when China imposes tariffs against the U.S. [Figure 4(ii)]. In the long run, the most important factor in explaining China's GDP result is an efficiency effect. Unlike the U.S., China has relatively high tariffs in the baseline. Impositions of tariff increases from a high base carry permanent large negative triangle/rectangle GDP losses.

A contrast between Figures 4(i) and (ii) is that U.S. tariffs significantly hurt Chinese GDP [Figure 4(i)] but Chinese tariffs have only a small negative effect on

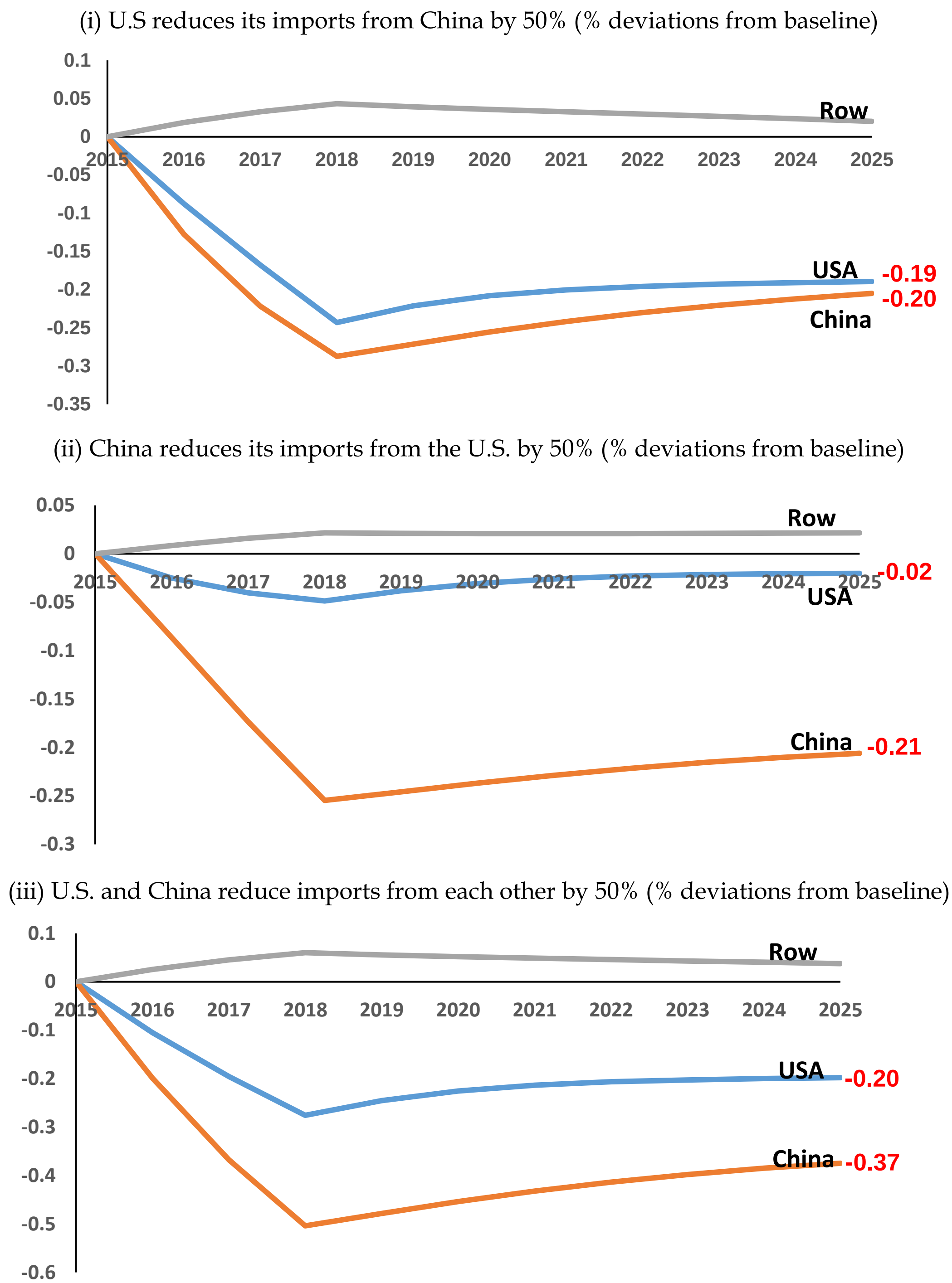


Figure 4. U.S.-China trade decoupling: effects on GDP

U.S. GDP [Figure 4(ii)]. Chinese exports to the U.S. relative to Chinese GDP are four times larger than U.S. exports to China relative to U.S. GDP. Thus, a 50 per cent loss of its exports to the U.S. imposes a much greater terms-of-trade loss for China and associated long-run reduction in its capital/labor ratio, than is the case for the U.S. when it loses 50 per cent of its exports to China.

Figures 4(i) and (ii) show small GDP gains to RoW. When the U.S. blocks Chinese access to U.S. markets, this opens opportunities for other countries to export to the U.S. Similarly, when China blocks U.S. access to Chinese markets, this opens opportunities for other countries to export to China.

The GDP results for mutual trade-decoupling in Figure 4(iii) are approximately an addition of those in Figures 4(i) and (ii). The 50 per cent reductions in U.S. imports from China and Chinese imports from the U.S. harm GDP in both counties but the damage is more pronounced for China than the U.S.

4.2. Comparison of financial decoupling and trade decoupling

With regard to the main question for this section, we see that the GDP effects for the U.S. and China in the 50 per cent trade-decoupling simulations are of the same order of magnitude as those in the 50 per cent financial-decoupling simulations: generally between plus and minus half a per cent.

What would happen if mutual trade decoupling were undertaken together with mutual financial decoupling?

For the U.S., mutual trade decoupling [Figure 4(iii)] would reinforce the negative long-run GDP effect of mutual financial decoupling: -0.20 per cent in 2025 for trade decoupling in Figure 4(iii) in addition to -0.29 per cent for financial decoupling in Figure 3A.

For China, mutual trade decoupling would largely eliminate the long-run GDP gain from mutual financial decoupling: -0.37 per cent in 2025 for trade decoupling in Figure 4(iii) largely offsetting the 0.40 per cent gain for financial decoupling in Figure 3A.

To confirm that it is legitimate to add results in this way, we ran an extra simulation in which the mutual 50 per cent financial-decoupling and trade-decoupling shocks are applied simultaneously. GDP results are given in Figure 5. For China, the long-run GDP deviation is 0.02 per cent, approximately the sum of the GDP deviations in 2025 for China in Figures 4(iii) and 3A (-0.37 and 0.40). Similarly for the U.S., the long-run deviation (-0.47 per cent) is approximately the sum of those for the U.S. in Figures 4(iii) and 3A (-0.20 and -0.29).

5. Concluding remarks

Over the last 25 years, GTAP has been used in literally thousands of analyses of policies in which a country aims to discriminate in favor or against trade flows with another country. By creating GTAP-Fin, we have extended the range of

GTAP applications to include analyses of policies in which a country aims to discriminate in favor or against financial flows with another country.

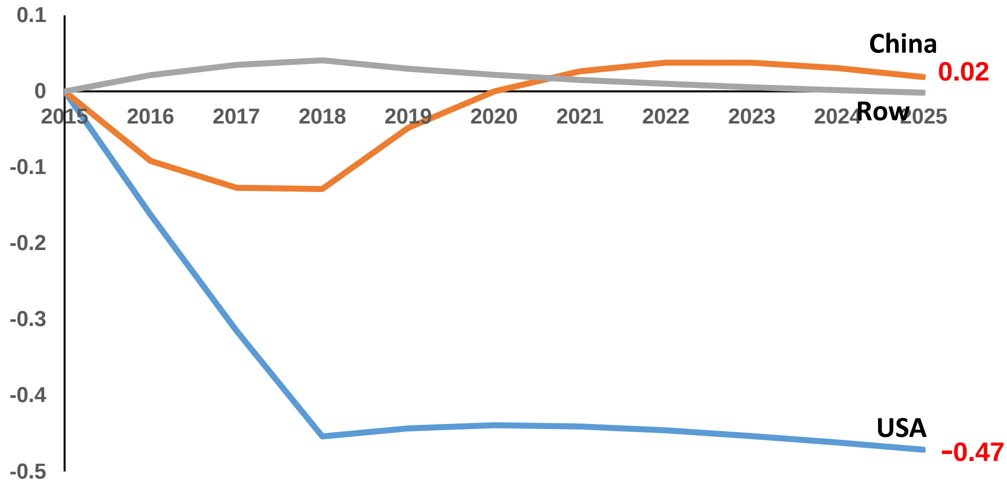


Figure 5. The U.S. and China decouple by 50 per cent in both finance and trade (GDP percentage deviations from baseline)

Using GTAP-Fin, we showed in section 3 that the U.S. would gain by limiting its financial flows to China, leading to a redirection of finance to the domestic economy. This would stimulate investment in the U.S. with favorable temporary effects on employment and favorable permanent effects on capital stocks, real GDP, wealth, and real wage rates. At the same time, investment in China would decline with negative effects on Chinese capital stocks, real GDP, wealth, and real wage rates.

Similarly, China would gain by limiting its financial flows to the U.S. and the U.S. would lose. China's long-run GDP gain from reducing its financial assets in the U.S. by 50 per cent (0.52 per cent, Figure 2A) easily outweighs its GDP loss from the U.S. reducing its financial assets in China by 50 per cent (0.12 per cent, Figure 1A). By contrast, the long-run GDP loss for the U.S. from China reducing its assets in the U.S. by 50 per cent (0.36 per cent Figure 2A) easily outweighs the U.S. GDP gain from reducing its assets in China by 50 per cent (0.06, Figure 1A). Thus, in a tit-for-tat situation in which each country reduces its financial-asset holding in the other by 50 per cent, China experiences a GDP gain (0.40 per cent, Figure 3A) while the U.S. experiences a GDP loss (0.29 per cent, Figure 3A). China wins in a tit-for-tat financial decoupling primarily because the value of Chinese financial assets in the U.S. is considerably greater than the value of U.S. financial assets in China. Another contributing factor, discussed in subsection 3.3.2, is the greater financial openness of the U.S. relative to China. This makes the sensitivity of the supply of funds to variations in expected rates of return higher in the U.S. than in China.

In section 4 we compared the effects of a 50 per cent mutual financial decoupling between the U.S. and China with those of a 50 per cent trade decoupling. This comparison showed that in terms of the size of GDP effects, financial decoupling is just as important as trade decoupling. However, unlike financial decoupling, trade decoupling reduces GDP in both countries [Figure 4(i)]. If trade and financial decoupling occurred simultaneously, then trade decoupling would add to the negative GDP effects of financial decoupling for the U.S. and effectively eliminate the gains for China (see Figure 5).

There are many directions in which the research in this paper could be extended and improved. An obvious area is the estimation of the asset-liability matrix (Table 1). As explained in subsection 2.2, we obtained genuine data for the row and column sums and for the U.S./China block. But the rest of the matrix was compiled by a RAS procedure. Further data work will be necessary before we can confidently extend the scope of applications of GTAP-Fin to encompass discriminatory financial policies involving countries apart from the U.S. and China. Another obvious area is the estimation of parameters controlling the substitutability for each region between different uses of available finance. In the present version of GTAP-Fin, substitutability is controlled by just one parameter (σ), set by judgement. Reassuringly, sensitivity analysis in the appendix shows that the qualitative conclusions in this paper are unlikely to be overturned by different substitutability assumptions within a realistic range. Nevertheless, this need not be the case for all potential applications of the model.

Other areas for future development of GTAP-Fin are suggested by existing financial modules in single-country CGE models.[10] These modules include disaggregation of financial instruments into loans, bonds, equity, cash, and special drawing rights & gold. There are also separate asset-allocating optimization specifications for households, banks, non-bank financial institutions, retirement funds, industries and government. Inclusion of these features in the GTAP framework would provide a model that could give insights into the international effects of monetary policies such as changes in Central bank cash rates and in capital adequacy ratios imposed on commercial banks.

[10] Papers describing and applying CoPS' single-country CGE models with financial modules include: Dixon et al. (2015), Giesecke et al. (2016 & 2017), and Nassios et al. (2019a & b).

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Appendix A. Sensitivity of results to variations in $\sigma - 1$

Figure 6 shows GDP deviations for the U.S. and China in 2025 generated in simulations with different values of $\sigma - 1$. This parameter controls the response of region r's end-of-year holding of assets in region s to variations in the rate of return that the financial agent in r expects from these assets relative to the average rate of return that the agent expects from its entire portfolio, see equations (7) and (7a).

Panel (i) in Figure 6 gives results for the effects of the U.S. reducing its financial assets in China by 50%, phased in from 2016 to 2018. With $\sigma - 1$ at 2, panel (i) reproduces the 2025 results for the U.S. and China from Figure 1A (0.06 and -0.12). Panel (ii) gives results for the effects of China reducing its financial assets in the U.S. by 50%. With $\sigma - 1$ at 2, panel (ii) reproduces 2025 results from

Figure 2A (-0.36 and 0.52). Panel (iii) gives results for the effects of both regions reducing financial assets in the other by 50%. With $\sigma - 1$ at 2, panel (iii) reproduces 2025 results from Figure 3A (-0.29 and 0.40).

In explaining the results in Figure 6, we start with the China graph in panel (ii). When China reduces its assets in the U.S. by 50 per cent, the initial impact is to increase China's supply of finance to other regions, including China, by about \$1.5 trillion (= 50 per cent of the U.S.-China entry in Table 2). At initial expected rates of return, about 84.26 per cent of this, or \$1.264t, supplements the supply of funds to investors in China itself: 84.26 per cent of China's non-U.S. financial budget is held in China [0.8426 = 40.79/(40.79+7.62), Table 2].

Figure 7 illustrates the implications of the extra supply of funds to China. In both the top and bottom halves of this figure, the curve marked D represents the demand for investible funds in China to be used for capital creation. This is downward sloping because more investment projects are financially feasible at lower expected rates of return. The line marked S represents the supply of investible funds to China. This is upward sloping because the supply of finance to China from domestic and foreign sources increases with higher expected rates of return. The initial equilibrium in both halves of the figure is at the point a.

In the two halves of Figure 7, we have drawn the D curve with the same slope. In the top half, the S curve is considerably more elastic than in the bottom half. In GTAP-Fin, the more elastic curve corresponds to a high value of $\sigma - 1$. With a high value, the financial agent in each region strongly increases its allocation of funds towards China in response to an increase in expected rates of return on these funds [equations (7) and (7a)]. The relatively inelastic S curve in the lower half of Figure 7 corresponds to a low value for $\sigma - 1$.

The impact effect of the extra supply of funds to capital creators in China from the 50 per cent reduction in Chinese assets in the U.S. is represented in Figure 7 as a horizontal rightward movement of \$1.264t in the supply-of-funds curve to China, from S to S′. This moves the equilibrium from a to b. With the elastic supply curve (top half), the reduction in the rate of return and the increase in investment in China are small relative to those with the inelastic supply curve (bottom half). This means that the boost to capital and consequently GDP is smaller with an elastic supply curve for funds than with an inelastic supply curve. This explains the China GDP results in Figure 6(ii). As we move to higher values of $\sigma - 1$ (higher supply elasticity), the GDP gains to China from restricting its asset holdings in the U.S. diminish.

For the U.S., panel (ii) of Figure 6 shows that higher values for $\sigma - 1$ reduce the GDP loss associated with Chinese withdrawal of finance. This can be understood in terms of a figure similar to Figure 7 but drawn for the U.S. The withdrawal of funds from the U.S. can be represented by a horizontal leftward movement in the supply-of-funds curve to the U.S. Higher values of $\sigma - 1$ (more elastic supply) mean that a given horizontal leftward movement in supply causes

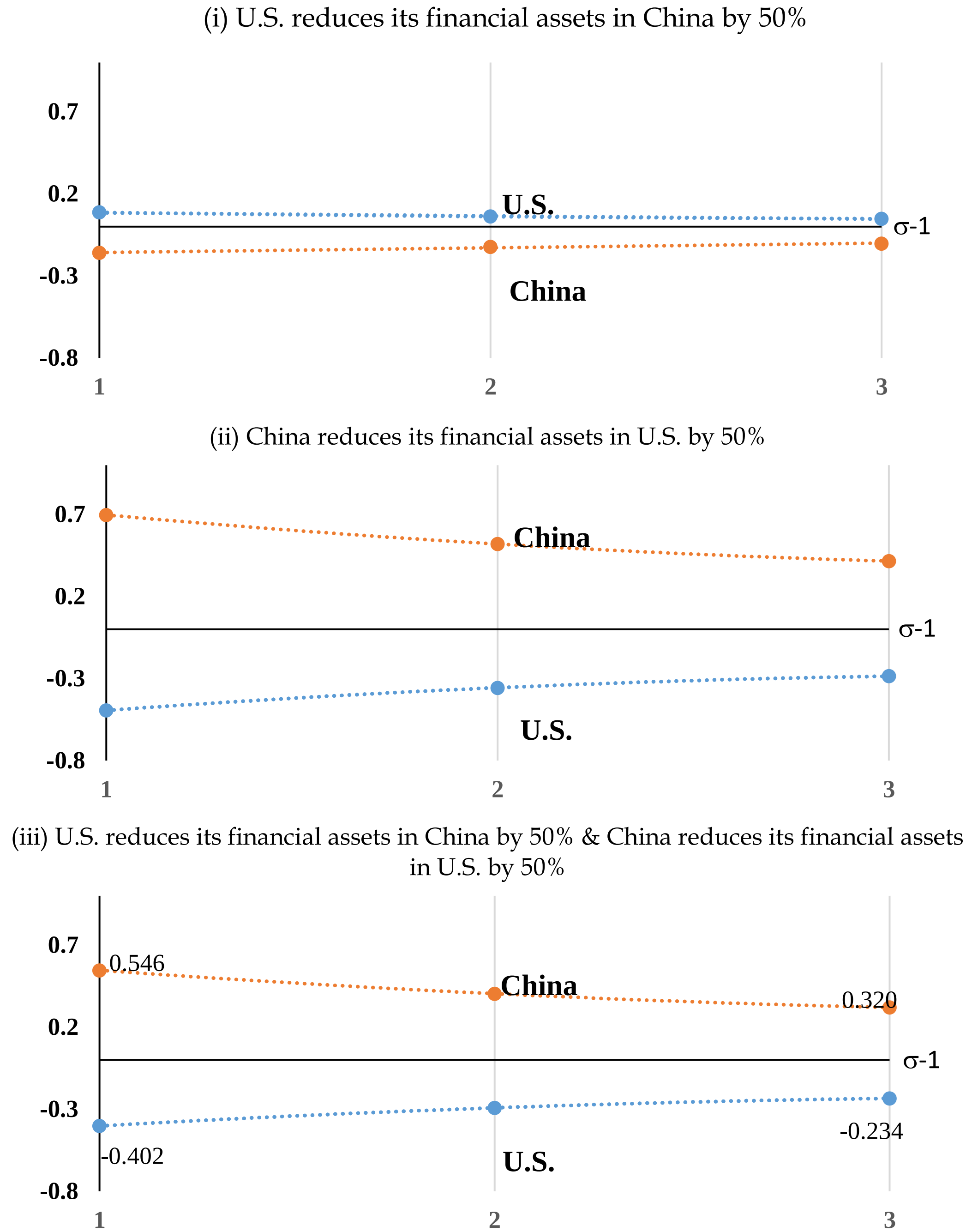

Figure 6. Financial decoupling with different values of $\sigma - 1$: % deviations in GDP in 2025

less increase in the rate of return and a smaller loss in investment, capital and GDP.

Qualitatively, panel (i) of Figure 6 tells a similar story to panel (ii), but with the regions reversed. The U.S. gains from restricting its assets in China but this gain diminishes as $\sigma - 1$ increases. China loses from U.S. withdrawal of its Chinese assets; but loses less for higher values of $\sigma - 1$. Quantitatively, the effects in panel (i) are much smaller than those in panel (ii). This was explained in subsection 3.3.2.

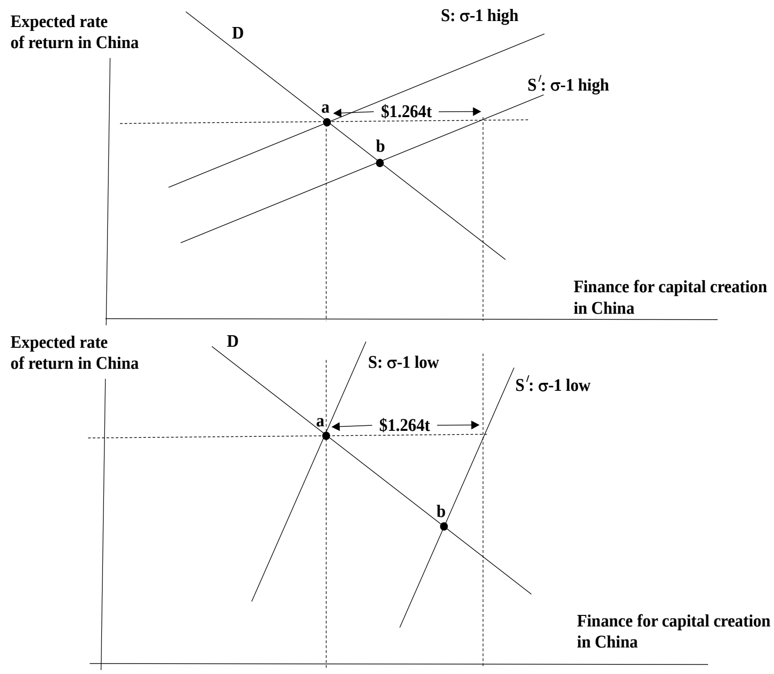

Figure 7. Demand and supply for finance in China: effects of a 50% reduction in China's assets in the U.S. with high and low values for $\sigma - 1$

The results in panel (iii) of Figure 6 are approximately an addition of those in panels (i) and (ii). Because the panel (ii) results are quantitatively much bigger than the panel (i) results, panel (iii) looks quite similar to panel (ii).

Figure 6 shows that the financial decoupling results analyzed in section 3 depend on our chosen value of 2 for $\sigma - 1$. However, this dependency is only moderate. In panel (iii), showing GDP effects of a 50 per cent mutual financial decoupling, a tripling of $\sigma - 1$, from 1 to 3, reduces the China GDP deviation by 41 per cent (from 0.546 per cent to 0.320 per cent) and increases the U.S. GDP deviation by 42 per cent (from -0.402 per cent to -0.234 per cent). With this degree of dependency, the qualitative results reported in sections 3 and 4 and summarized in section 5 would not be overturned by different settings of $\sigma - 1$ within a plausible range.