An investment determination mechanism with segmented capital markets

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Abstract

In the standard GTAP model, regional investment is allocated via a global bank under which either the expected rate of return is equalized across regions or the net investment growth rate is equalized across regions. In a typical CGE baseline with long term recursive dynamics, this paper shows that this global bank approach can lead to unrealistic investment growth and volatile current accounts (i.e., trade balances) projections even in major economies. To tackle these issues, this paper introduces a segmented capital markets approach where regional investment comes from not only the global/international bank but also domestic banks such that regional investment and savings are well connected. The paper shows that the proposed approach leads to well-controlled investment growth and trade balance developments.

Key words: computable general equilibrium, global bank, segmented capital markets, investment, trade balance

1. Introduction

In a typical computable general equilibrium (CGE) model, the stability of the projected movement in national account indicators/components depends on, among other things, how these indicators interact with each other. A mechanism used to determine one of these indicators may not just affect the stability of the projections of this particular indicator. It may also affect the stability of the projections in the other related indicators. In other words, if the projections for one of these macro indicator have issues, the issues may not just be due to the mechanism applied in determining this particular indicator. The issues may also come from the other closely related indicators.

In the standard GTAP model and other CGE models running with a GTAP core (e.g. MAGNET), two of the key indicators on the expenditure side of the national account, private and government consumptions, are explicitly tied to the income side of the national account, where changes in these consumptions are determined at the regional level. These explicit ties at the regional level ensure that the expenditure side solutions for private and government consumptions are able to take advantage of the stability offered on their income side counterparts. This is because in GTAP the regional income is allocated across its components including private expenditure, government expenditure, and savings, subject to an elasticity-weighted Cobb-Douglass utility function which by its nature ensures a stable movement in its components.

While an explicit connection between the expenditure side and the income side at the regional level exists for consumptions, there is no such explicit connection for another key component on the expenditure side, investment. In the standard GTAP and other CGE models that run with a GTAP core (e.g. MAGNET), regional investment is allocated through a virtual global bank where the savings collected from all model regions is converted into investment under the "Walras Law". The global investment is then allocated across regions subject to either an equalization of the expected rate of return across regions or an equalization of net investment growth across regions. Under the global bank approach, regional investment is not explicitly connected with regional savings, meaning that the projected movement in regional investment may or may not deviate greatly from the movement in regional savings and this deviation will inevitably interact closely with the remaining macro indicator, regional trade balance (export minus import), given the stable movements in regional consumptions. This implies that investment must fight with trade balance at the regional level in order to maintain a national account identity. Thus, the stability in regional investment growth critically hinges on, and also critically affect, the stability of trade balance movements.

In the standard GTAP model, changes in trade flows are governed by the Armington trade structure where imports are nested into two levels, with the first level determining the imported vs domestic use and the second level determining the imports across source regions. In response, regional export simply follows the import demand in destination regions, subject to market clearing in the exporting region. Since the Armington elasticities of substitution especially for the imports across source regions are rather high (3-10 depending on commodities), this leads to trade flows and particularly export flows very sensitive to a price change in global markets. Given the sensitivity of the trade system, whether the model can produce sensible projections on trade and trade balance movements hinges critically on how sensible the projected investment growth can be and how regional investment moves relative to regional savings as any change in the capital account will be directly reflected in the current account (i.e. trade balance).

In some other CGE models where the trade system is not based on the Armington structure as in GTAP, trade balance movements may not depend so critically on investment changes. For instance, in the ORANI-G model of the Australian economy (Horridge, 2000), where demand is also divided into domestic and imported but the imports are not distinguished by source region. Likewise, export demand is not governed by an Armington substitution as it is in GTAP. Instead, it is only given by a simple demand function which in general leads to a rather stable export response. In this model, investment allocation is also governed by a rates of return equalization condition. However, since stability has been secured on trade balance movements, alongside well-controlled consumption changes, the investment response as a residual among the macroeconomic components can only remain stable. This kind of stability mechanism at the macro level, however, is not available in the existing GTAP.

Without an explicit connection with the income side or a stable trade system, we can only hope that the parameter controlling the responses in investment and the expected rate of return can be properly tuned thus leading to reasonable investment responses. However, a closer look at the investment and rate of return determination mechanism reveals that this can be a daunting task. If we combine all the associated equations used to determine regional investment including the expected rates of return equalization, the determination of regional expected rate of return, and the relationship between capital stock (start-of-period & end-of-period) and investment, we may derive one combined equation to express regional investment growth as the function of regional capital stock growth and the relative change between the globally equalized expected rate of return and the regional current rate of return, with the relative change being multiplied by a combined coefficient consisting of the reciprocals of the response parameter, RORFLEX, and the ratio of gross investment to end-of-period capital stock, INVKERATIO.

In this combined equation, we can see more clearly the issues associated with the calibration of the response parameter which coordinates the interaction between investment and the expected rate of return. First, the growth mode varies greatly across regions as reflected through the assumed GDP growth rates and the current rates of return. If we have a uniform response parameter and the expected rate of return for all the model regions, it is highly unlikely to get a reasonable investment response matching the region's growth profile. If we increase the value of the response parameter to minimize the impact of the relative rate of return on investment such that investment growth can follow capital stock growth more closely, we may end up having a wild response in the expected rate of return rather than a reasonable investment response. This is due to the way the global expected rate of return, rorg, is determined. As a variable determined by the "Walras Law", rorg essentially captures all the residual responses of the model. This implies that when the response parameter RORFLEX is adjusted, rorg may respond to the adjustment even more greatly than investment does. This leaves us with possibly the only option which is to calibrate a region specific response parameter taking into account the growth profile in each individual region. This parameter may also be period specific as the growth profile especially in a relative sense may change over time. Undoubtedly, this can be a daunting and very time consuming task for modellers.

Under the global bank approach, switching to the regional net investment growth rate equalization does not lead to more reasonable results either. The reason is similar to what is shown above for the expected rate of return equalization. Since the heterogenous growth mode across regions has been built into the assumed GDP growth rates, a further equalization of the regional net investment growth rate adds homogeneity to the regional growth which will inevitably lead to some strange trade balance movements to explain the heterogeneity across regions. As shown later in the paper, the experiments we conduct, whether they are based on the expected rate of return equalization or the net investment growth rate equalization, or the different values of the response parameter, all have issues in the projected investment growth and trade balance movements, even in some major economies in the world.

Another traditional way to solving these issues under the global bank approach is to exogenously fix the current account balance or let the current account components (export, import, or both) follow certain existing trends (e.g. GDP growth) in certain troubling model regions. While this may help bring investment growth back to a normal track, one has to admit that this is a rather patchy way than a systematic approach to fixing issues since additional assumptions may need to be made as to how the model would accommodate to such an exogenous shift in the current account. This calibration procedure usually requires a swap with another exogenous variable in the model such as a productivity change variable or a preference shifter. Such swaps may not work in all the situations as the model solved this way may have particular requirements for the structure of the base data. In certain regions especially some smaller regions, data quality is often an issue so a seemingly regular swap can unintentionally lead to a crash of the model, which has been experienced multiple times in our experiments.

Unlike all the above solutions, we introduce in this paper an alternative investment determination mechanism to replace the existing global bank approach. In this new approach, domestic/regional banks are added to the MAGNET core (i.e. the standard GTAP), the existing global bank being transformed into an international bank, so we now have a two-level banking system with segmented capital markets. With regional banks in place, investment will be able to connect explicitly with savings at the regional level. This connection clears the capital market in each region where the domestic and foreign sources of investment and savings are distinguished using the financial flows data derived from MAGNET's wealth module. Since the expected rate of return is not required anymore to equalize across regions, the existing equations associated with the expected rate of return only work as non-essential summary equations. An alternative mechanism is also established on the regional price linkage between investment and savings where an endogenous scalar variable is introduced to equalize the relative price change between investment and savings across regions, As a new variable determined by the Walras's law, this variable plays a role previously played by the global expected rate of return. We reinterpret this relative price equalization mechanism as an equalization of risk premium across regions.

An important advantage of the new investment determination mechanism is that investment growth at the regional level will be able to tap into the stability offered on the savings side as growth in regional savings is bound by a utility-elasticity-weighted Cobb-Douglas income allocation structure which in general behaves in a rather stable way. When regional investment and savings are explicitly connected, the domestic and foreign shares govern to what extent a stable change in regional savings will be reflected in the corresponding change in regional investment, a key stabilizer missing in the global bank approach. This important implication has been confirmed with the updated simulation results where the abovementioned issues disappear not only in those major economies but also in smaller regions. Clearly, this new mechanism offers a more systematic solution for the trade-off issues associated with the macroeconomic structure, without having to resort to any patchy solutions based on additional assumptions. Compared to the existing expected rate of return equalization approach, the proposed mechanism frees modellers from the hassle of having to calibrate a region-specific and possibly period-specific response parameter which can be a daunting task in a typically time-consuming baseline calibration practice.

The rest of the paper proceeds as follows. We first discuss the existing global bank approach in Section 2; then compare this approach with a similar approach in Section 3. In Section 4, we introduce the proposed segmented capital markets. In Section 5, we describe our model and the baseline setup. The simulation results are presented in Section 6. Section 7 concludes.

2. The global bank approach

In the standard GTAP, regional investment is allocated through a virtual global bank where the saving collected from all regions is converted into investment under the "Walras Law" which immediately implies that global saving equals global investment in the model. The global bank allocates investment across regions subject to a certain rule. There are currently two options available in the model for regional investment allocation: one is the equalization of the expected rates of return across regions and the other is the equalization of regional net investment growth rates.

As the default mechanism, the expected rates of return equalization approach is reflected through the following equations. The first one defines the expected rate of return in each region as

$$rore(r) = rorc(r) - RORFLEX(r) * [ke(r) - kb(r)] \quad (1)$$

where rore stands for the expected rate of return for the investment in region r; rorc represents the current rate of return, given by the change in rental price relative to the change in capital goods price; kb and ke are the percentage change in capital stock at the start of the year and at the end of the year, respectively; RORFLEX is a response parameter.

The equalization of the expected rate of return across all the model regions is given by

$$rore(r) = rorg \quad (2)$$

where rorg denotes the global expected rate of return which is determined by the "Walras' law" for the omitted market.

The relationship between start of year capital stock, kb, and end of year capital stock, ke, as shown in equation (1), is given by

$$ke(r) = INVKERATIO(r) * qinv(r) + [1.0 - INVKERATIO(r)] * kb(r) \quad (3)$$

where qinv denotes regional investment, and coefficient, INVKERATIO, stands for the ratio of investment to end of year capital stock.

If we combine all the above equations used to determine the allocation of investment based on the equalization of the expected rates of return, we may derive a combined equation as

$$qinv(r) = kb(r) - \frac{1}{RORFLEX(r)*INVKERATIO(r)} * \left(rorg - rorc(r)\right) \quad (4)$$

where regional investment growth is expressed as the function of regional capital stock growth and the relative change between the globally equalized expected rate of return and the regional current rate of return, with the relative change being multiplied by a combined coefficient consisting of the reciprocals of the response parameter, RORFLEX, and the ratio of gross investment to end of year capital stock, INVKERATIO.

Among the variables in this equation, kb is accumulated from past investments, rorg is determined by the "Walras Law" for the omitted global investment and savings market, and rorc captures the relative change between capital rents and capital goods prices. As can be seen, none of these variables are directly connected with regional saving. Thus, there is no guarantee offered in this equation that changes in regional investment will not deviate greatly from regional saving.

In this combined equation, investment determination is governed by the combined response coefficient, 1/(RORFLEX(r)*INVKERATIO(r)). We may wish to consider getting an appropriate response coefficient to enable a sensible investment response. This is however difficult to do so. Since the default parametric value for RORFLEX is 10 and INVKERATIO ranges from 0.04 to 0.08 in the base data, this gives a combined response coefficient value of 1.25-2.5, approximately. Given the responsiveness of this combined coefficient, we might end up having an unrealistically high investment response if the relative price change is sufficiently large. If we consider increasing the value of RORFLEX instead, such that the combined response coefficient is smaller, it is still difficult to get a sensible investment response. This is due to the way the global expected rate of return, rorg, is determined. As a variable determined by the "Walras Law", rorg essentially captures all the residual responses of the model. In this sense, rorg, and its counterpart at the regional level, rore, is actually determined by investment, and not the other way around. That is, a high investment growth would in general cause a lower expected rate of return. This kind of mechanism is different from the usual demand response to a price change where the agent who demands is considered a price taker in the model having no influence on the prices faced. The unique mechanism associated with the rore and rorg determination implies that when the response parameter RORFLEX is adjusted, rorg may respond to the adjustment and may even respond more greatly than investment growth *per se*, making it difficult to get a properly calibrated parameter. Moreover, since regions may have a different growth mode, investment growth rates may differ greatly across regions and over time, this could mean a properly calibrated parameter needs to be varying across regions and over time, thus adding further difficulties in parameterization of the model.

3. A comparison with ORANI-G

It can be helpful to compare the global bank approach with the investment determination approach used in the ORANI-G model (Horridge, 2000) where investment allocation is also subject to a rates of return equalization condition. ORANI-G is a widely used CGE model of the national economy, where the percentage change form of sectoral investment is given by

$$x2tot(i) - x1cap(i) = finv(i) - 0.33*(omega - r1cap(i)) \qquad (5)$$

Where x2tot denotes investment growth at the sectoral level; x1cap denotes sectoral capital stock growth; finv is exogenous shifter; omega is defined as economy-wide rate of return; and r1cap stands for capital rents growth.

As can be seen, equation (4) is very similar to equation (5) in terms of the way investment is determined. The only differences are that investment is determined at the regional/national level in equation (4) but at the sectoral level in equation (5); rorg represents a rate of return at the world level while its counterpart, omega, represents a rate of return at the national level. Therefore, the two equations reveal that the investment determination mechanism in the standard GTAP is very similar to the one in ORANI-G.

Another similarity in ORANI-G is that sectoral investment also interacts with international trade to settle the national account. In ORANI-G, import demand is governed by a similar Armington structure that distinguishes domestic commodities versus imports. However, export is not governed by an Armington substitution as it is in GTAP. Instead, export demand is given by a simple demand function:

$$x4(c) - f4q(c) = -ABS[EXP\_ELAST(c)]*[p4(c) - phi - f4p(c)] \qquad (6)$$

where x4 denotes export demand; p4 denotes export prices; phi denotes the exchange rate converting to the foreign currency; f4q and f4p are exogenous shifters allowing respectively for horizontal (quantity) and vertical (price) shifts in the demand schedules. The elasticity given by -ABS[EXP_ELAST ensures that sectoral exports are declining functions of their prices in foreign currency.

Since export demand in equation (6) only responds to export prices subject to the given elasticity, this is rather different from the export determination in GTAP where an Arminton level-two substitution between different destination regions/countries is also needed. As such, the export responses in ORANI-G can be rather stable compared to the export responses derived in GTAP. Consequently, the investment growth in ORANI-G, when interacting with stable trade flows, can get a stable equilibrium solution. By contrast, the export determination in GTAP based on the Armington level two substitution across regions can hardly lead to stable developments in dynamic versions unless there are stable solutions already on the investment side.

4. Segmented capital markets

Considering the unique trade structure in GTAP, we introduce in this paper a new mechanism on investment determination in an attempt to stabilize investment growth, such that the derived trade responses become stable as well. As a replacement of the global bank approach in GTAP, we introduce a two-level banking system that steers how investment is allocated from saving, both domestically and internationally. In this two-level banking system, there are national(domestic) banks as well as an international bank, with each level controlling different capital flows. National banks set up the price to clear the domestic capital markets such that all domestic saving goes to domestic investment. The international bank sets up a price to clear the international capital market such that foreign savings coming from all countries/regions are exhausted by foreign investment in all countries/regions. This implies that the price set up to clear the international market may be different from the prices clearing the national/domestic markets. While the two bank levels have their respective price determination mechanisms, all the capital markets are cleared simultaneously, as reflected in the following market clearing condition:

$$\mathrm{qsave}(r) = \mathrm{NETINVDOM}(r)/\mathrm{SAVE}(r)*\mathrm{qnetinv}(r) + (1-\mathrm{NETINVDOM}(r)/\mathrm{SAVE}(r))*\mathrm{sum}(g,\mathrm{REG}, \mathrm{NETINVMSHR}(g)*\mathrm{qnetinv}(g)) \quad (7)$$

where the lower case denotes variables expressed in percentage changes while the upper case denotes coefficients expressed in levels. qsave(r) represents a percentage change in real saving in region r; qnetinv(r) represents a percentage change in real net investment in region r; NETINVDOM(r)/SAVE(r) stands for the share of saving that goes to domestic investment; and NETINVMSHR is the share of foreign net investment in region r in the world's total net investment.

Equation (7) states that regional saving goes to two different destinations: one is the domestic market and the other is the international market. The overall change in regional saving is thus a weighted average change in domestic saving which is converted to domestic investment and in foreign saving which in converted to foreign investment. Note that the conversions per se do not change the real capital flows so we do not need two different denotations in the right side of the equation respectively for saving and for investment. For simplicity, we assume that foreign investment moves in line with domestic investment so that we do not need two different denotations respectively representing the percentage change in domestic investment and the percentage change in foreign investment.

With equation (7), capital markets are segmented into two different levels reflected through different capital flows. We use market shares data to distinguish these capital flows. These data are based on the foreign direct investment (FDI) data collected from the United Nations Conference on Trade and Development (UNCTAD). We use these data to account for foreign assets and liabilities associated with foreign savings and investment. The assets and liabilities defined in the model are different from the full assets and liabilities defined in a more general way which may include other financial data such as securities. The data we use is consistent with the standard GTAP data on capital stock which in principle only accounts for physical capital such as machines and factories rather than pecuniary capital such as securities.

Apart from the above newly introduced equation, we also modify an existing equation which links saving prices with investment goods prices

$$\mathrm{psave}(r) = \mathrm{pinv}(r) + \mathrm{sum}\{s,\mathrm{REG}, [[\mathrm{NETINV}(s) - \mathrm{SAVE}(s)] / \mathrm{GLOBINV}] * \mathrm{pinv}(s)\} \quad (8)$$

where pinv and psave denotes the percentage change in regional prices respectively for investment goods and saving. In our new approach, we modify this equation as

$$\mathrm{pinv}(r) = \mathrm{psave}(r) + \mathrm{walrasshift} \quad (8')$$

where walrasshift is introduced as a scalar variable determined by the "Walras Law" for the omitted market. We use this variable to replace the existing component in equation (8) that captures the relative price change using the weighted change in investment goods prices. With this replacement, we reinterpret this equation as a equalization condition since it equalizes the relative change between investment goods price and saving price. If we consider saving price as a risk-free reserve price and investment goods price in general as a markup on saving price to reflect additional risks associated with investment, the markup essentially captures a risk adjusted investment return, i.e., a risk premium, accrued to investors. Regions may differ in their risk profiles and thus risk premiums may be different in different regions. When investors take into account region-specific risk profiles to make an investment decision, Thus, the equalization condition imposed in equation (8') states that while the adjustment to the risk premium, which may be triggered by a change in investment demand or supply, is considered proportional and equalized across regions. For instance, consider two regions, one with a 10% risk premium and the other with a 20% risk premium. If there is an increase of 1% in risk premiums, each region will have the same percentage of this adjustment meaning that the risk premium in the two regions becomes 10.1% and 20.2%, respectively.

With equations (7) and (8'), we replace the existing global bank approach with segmented capital markets. There are two important benefits from this new approach. First, equation (7) connects regional investment with regional saving through shares-weighted market clearing. This enables the model to tap into the stability offered on the saving side where the allocation of income is subject to a utility-elasticity-weighted Cobb-Douglass function which in general projects rather stable income flows for its components including private consumption, government consumption, and saving. As mentioned earlier, once the stability for the capital account that involves investment and saving is secured, the stability for the current account will follow.

Second, this new approach frees modellers from potentially having to calibrate the response parameters that are needed under the global bank approach where the expected rates of return are equalized across regions. Depending on the heterogeneity, the calibrated parameters can be region and/or period specific in order to get reasonable investment growth and movements in trade balances. With our new approach, however, such a calibration is not needed as our new equations do not introduce any parameters to be calibrated or estimated.

5. Model aggregation and baseline setup

We implement the proposed segmented capital markets in MAGNET, a multiregional, multisectoral, recursively dynamic CGE model of the world economy. The model version we use is different from the standard version (Woltjer et. al., 2014) as it incorporates the latest development of the model as documented by Cui et al. (2024). The current model code is based on GTAP's model version 7 and the model's database is based on GTAP's database version 11, with 2017 as the base year. Since our intention is to test the robustness between different investment determination mechanisms, we first want to see which mechanism can produce more sensible projections for major economies so we have individual regions in the model's aggregation covering all the major economies such as North America (US and Canada), EU (all the 27 EU member states), and China (Mainland China and Hong Kong). On the other hand, we also want to test the robustness for some regions that tend to be very sensitive to model assumptions, so we include Brazil, Latvia, and Other Southern Africa (incl. 14 countries) as individual regions in the aggregation. For the remaining countries, we group them into two regions: Rest of Southern America, and Rest of World). In total, we have 8 model regions aggregated from 141 standard GTAP regions and 96 commodities aggregated from 131 standard MAGNET commodities.

Table 1: Assumed GDP growth rates in the baseline (%)

	2017-2023	2023-2030	2030-2040	2040-2050	2017-2050
World	14.8	24.2	31.7	20.9	127
EU	7.5	12.5	16.1	15.6	62.4
North America	9.9	13	20.6	12.7	68.9
China	34.8	38.2	44.2	16.8	213.9
Brazil	8	25.4	36.5	19.7	121.4
South America	8.5	21.8	27.5	28.5	116.4
Latvia	10.2	20.2	23.1	12	82.6
Southern Africa	21.6	44	45.5	60.3	308.6
Rest of World	14.4	30.5	38.3	28.8	165.8

Source: MAGNET database.

The baseline we construct reflects long term economic developments with the projection period spanning from 2017 to 2050 which is split into four projection periods. The macroeconomic assumptions for the baseline is based on the so-called "middle of the road" shared socio-economic pathway (Fricko et al., 2017). Under this pathway, GDP growth rates reflect medium-level challenges faced by the world economy (see Table 1). Population growths are also expected to face medium-level challenges and labor supply reflects the expected change in the working age population throughout the projection period. For simplicity, capital supply is assumed to follow regional GDP growth as this pattern is close to what is indicated by the Penn World Table for historical observations (Feenstra et al., 2015)

Alongside these SSP2 macroeconomic assumptions, we also implemented several other standard baseline shocks including land productivity growth, feed input efficiency improvements, waste collection developments, and the EU's Common Agricultural Policy real first pillar budget reduction (2% annually). All these baseline assumptions and the associated shocks are applied equally to all model versions meaning that the only differences between these models are the investment determination mechanisms which would make a meaningful comparison for the results between different model versions.

6. Simulation results

The simulation results we compare are based on different model versions associated with different investment determination mechanisms. Specifically, we have the following model versions to compare:

- R10: with the default response parameter RORFLEX = 10, so the combined response coefficient value shown in equation (4) ranges 1.2~2.5 approximately.
- R100: with the default response parameter RORFLEX = 100, so the combined response coefficient value shown in equation (4) ranges 0.12~0.25 approximately.
- NINV: equalization of net investment growth across regions, which replaces the equalization of expected rates of return across regions.
- SCM: segmented capital markets

When presenting individual model regions, we only focus on the results for major economies as these results will have the most significant impacts on resource allocations around the world. We do not present smaller regions here as we do not wish that one of the model's key mechanisms is influenced too much by possible "small region" effects as some smaller regions may have less quality of data which may affect the normal judgement on a chosen mechanism for investment determination.

We report major macroeconomic indicators on both the expenditure side and the income side that include private consumption, government consumption, savings, investment, and net trade (export – import). The projected results for private consumption and government consumption are reported in Tables 2 and 3 respectively. As can be seen, the projected growth rates for private and government consumptions are rather close between different model versions, indicating a stable consumption developments which are not sensitive to different assumptions on investment determination mechanisms. As mentioned earlier, this stability results from the established connections between income and expenditure, which enables the consumption side to take advantage of the stability offered on the income side, where private and government expenditures and savings are bound by a utility-elasticity-weighted Cobb-Douglass income allocation. Table 4 shows stable savings growth rates which also do not change significantly across model versions.

Table 2: Projected private consumption growth (%)

	Model	2017-2023	2023-2030	2030-2040	2040-2050	2017-2050
EU	R10	7.2	11.5	15.3	15.3	59
	R100	7.4	11.9	15.8	15.5	60.7
	NINV	7.3	11.9	15.9	15.5	60.7
	SCM	7.3	11.7	15.5	15.3	59.6
North America	R10	9.6	12.4	20	12.7	66.6
	R100	10	13.1	20.8	13.1	70
	NINV	10.2	13.6	21.6	13.8	73.2
	SCM	9.9	13.1	20.7	13	69.6
China	R10	27.6	30.6	37.3	14.4	161.7
	R100	25.4	27.6	33.1	12.8	140.2
	NINV	24.9	27.2	32.7	12.8	137.9
	SCM	25.6	27.8	33.5	12.9	142.1

Source: MAGNET simulation results.

Table 3: Projected government consumption growth (%)

		2017-2023	2023-2030	2030-2040	2040-2050	2017-2050
EU	R10	8.2	13.8	17.1	15.9	67.1
	R100	8.3	14.1	17.5	16.1	68.4
	NINV	8.3	14	17.5	16.1	68.4
	SCM	8.2	13.9	17.2	16	67.6
North America	R10	10.3	13.7	21.6	13.1	72.5
	R100	10.6	14.2	22.1	13.4	74.9
	NINV	10.7	14.5	22.7	13.8	77.1
	SCM	10.6	14.1	22.1	13.3	74.6
China	R10	36.6	36.7	39.4	13.7	196.1
	R100	34.1	34.1	36.1	12.6	175.6
	NINV	33.6	33.8	35.9	12.6	173.4
	SCM	34.3	34.3	36.4	12.7	177.3

Source: MAGNET simulation results.

Table 4: Projected savings growth (%)

	Model	2017-2023	2023-2030	2030-2040	2040-2050	2017-2050
EU	R10	10.1	18.8	22.4	21.9	95.2
	R100	10.7	21.3	27	23.9	111.2
	NINV	10.3	20.6	25.7	23	105.6
	SCM	10.6	21.2	26.7	23.8	110.1
North America	R10	11.6	15.8	25.5	15.4	87.2
	R100	12.8	19.3	30.6	17.3	106
	NINV	12.9	19.4	30.2	16.6	104.5
	SCM	12.7	19.2	30.6	17.3	106
China	R10	54.2	58	63.6	24.1	395.1
	R100	50.7	56	63.2	24.2	376.5
	NINV	49.5	54.7	60.9	23.2	358.4
	SCM	51.1	56.6	63.9	24.5	382.7

Source: MAGNET simulation results.

The projected investment growth shown in Table 5 tells a rather different story. When regional expected rates of return are equalized with the response parameter RORFLEX equal to the default value 10, as shown in scenario R10, the model projects very low investment growth in the EU and North America, with North America even experiencing negative investment growth over two projection periods. The projected investment growth rates in these two regions are also significantly lower than the corresponding savings growth rates shown in Table 4. On the other hand, investment growth in China is very high, well over the assumed GDP growth and the projected savings growth over the same periods.

If RORFLEX increases to 100 (scenario R100), investment growth in the EU appears to be at the other extreme as it well exceeds the corresponding GDP growth, but this type of investment-led growth mode is not typical for a developed economy such as the EU, nor what is expected when the response parameter is adjusted. When RORFLEX increases from 10 to 100 leading to a lower response coefficient in equation (4), we might expect an increase in investment growth sustained by a less negative relative price effect, -1/(RORFLEX(r)*INVKERATIO(r))*(rorg-rorc(r)). However, as a Walras residual, rorg surprisingly turns into negative causing an overall positive relative price effect, which thereby leads to an even higher investment growth in the EU and North America. The inconsistent movements between the expected rate of return and the current rate of return in this situation, as shown in Tables 6 and 7, highlights the difficulty in adjusting the response parameter in order to get an appropriate investment response.

If we switch from expected rates of return equalization to net investment growth rates equalization, as shown in scenario NINV, investment growth in North America turns out to be very high leading again to a growth mode that should not be sustained in such a developed economy. This type of investment determination mechanism is also not conceptually desirable especially in a dynamic model since this would imply a homogenized growth mode across regions which clearly fails to distinguish investment-led economies from consumption-led ones.

As we can see, the investment growth in all the three major economies only becomes reasonable in scenario SCM where segmented capital markets are introduced to replace the global bank approach. The projected investment growth under this approach moves more closely with its savings counterparts while remaining consistent with the corresponding GDP growth. This joint agreement also implies that the growth mode in the respective economy has been taken into account.

Table 5: Projected investment growth (%)

	Model	2017-2023	2023-2030	2030-2040	2040-2050	2017-2050
EU	R10	2.4	4.4	4	17.4	30.5
	R100	9.7	17.3	22.4	19.6	88.3
	NINV	9.5	16	21.2	17.7	81.3
	SCM	7	12.1	14.6	16.2	59.7
North America	R10	2.3	-4.1	-0.3	0.7	-1.6
	R100	11.4	16.1	25	15	85.9
	NINV	15.7	23.8	33.4	19.6	128.5
	SCM	10.8	15.1	24	14.4	80.9
China	R10	72.5	64.5	64.8	22.8	474.6
	R100	40	44.9	51.7	19.9	269
	NINV	31.7	40.2	47.4	21.5	230.6
	SCM	43.7	48.1	55.1	21	299.4

Source: MAGNET simulation results.

Table 6: Projected change in expected rate of return (%)

	Model	2017-2023	2023-2030	2030-2040	2040-2050	2017-2050
EU	R10	5.55	12.54	15.74	8.05	48.54
	R100	-5.27	-9.9	-13.21	-8.05	-31.89
	NINV	2.57	8.12	9.75	8.22	31.71
	SCM	3.57	9.5	12.01	8.61	37.97
North America	R10	5.55	12.54	15.74	8.05	48.54
	R100	-5.27	-9.9	-13.21	-8.05	-31.89
	NINV	0.01	0.73	2.03	-0.51	2.26
	SCM	1.95	4.38	6.42	3.14	16.81
China	R10	5.55	12.54	15.74	8.05	48.54
	R100	-5.27	-9.9	-13.21	-8.05	-31.89
	NINV	25.18	25.83	25.76	9.69	117.29
	SCM	18.7	21.4	21.25	9.68	91.65

Source: MAGNET simulation results.

Table 7: Projected change in current rate of return (%)

	Model	2017-2023	2023-2030	2030-2040	2040-2050	2017-2050
EU	R10	3.32	9.16	11.06	8.67	36.11
	R100	3.43	9.6	11.79	9.09	38.25
	NINV	3.42	9.66	12	9.18	38.7
	SCM	3.34	9.35	11.36	8.85	36.97
North America	R10	1.33	3.6	6.72	3.67	16.14
	R100	2.55	5.69	8.48	4.18	22.49
	NINV	3.11	6.74	9.52	4.05	25.42
	SCM	2.44	5.5	8.25	4.07	21.76
China	R10	27.86	32.57	33.69	14.55	159.58
	R100	23.92	27.53	28.15	12.78	128.4
	NINV	23.18	27.06	27.67	12.79	125.4
	SCM	24.25	27.9	28.63	12.97	130.94

Source: MAGNET simulation results.

As mentioned earlier, the key to the investment determination mechanism is to get stable movements in both investment and trade balance (i.e. the current account in our model) as the two inherently interact with each other in the model. In the default model R10, movements in trade balance can get wild as shown in Table 8 for China and North America where trade balances flip into an opposite territory. Such movements are not expected in a typical baseline without special shocks. In scenario R100, the trade balance in the EU keeps shrinking over time while its growth in China becomes very high. It should be noted that a significant reduction in trade balance is not really expected since the model and its baseline settings do not indicate any opposite movement in trade balances. In other words, with the standard model specification and the assumption on a growing economy around the world, we expect to see steadily growing trade balances as well, whether the balances are positive or negative.

In the homogenized net investment growth scenario, NINV, the trade balance in the EU is still shrinking over the first three periods and then suddenly rising in the final period. On the other hand, the change in trade balance in North America and China becomes extremely high meaning that the trade balance in North America will become very negative while it will become very positive in China. Clearly, these somewhat idiosyncratic developments in trade balance have their connections with ill-controlled investment growth as mentioned above.

With segmented capital markets, SCM, we can see that all these issues are gone. Trade balance developments in all the three major economies behave as expected. That is, the percentage changes in trade balance in each region and projection period are all moderately positive meaning that the regions with initial trade surplus including the EU and China will see their trade surplus expanded further while North America initially with a trade deficit continues with expanding deficits. This would be expected given the model's capacity and the assumptions made in the baseline.

Table 8: Projected change in trade balance (%)

	Model	2017 (million USD)	2017-2023 (%)	2023-2030 (%)	2030-2040 (%)	2040-2050 (%)	2017-2050 (%)
EU	R10	440901	47.3	55.6	52.5	12.9	294.8
	R100	440901	-2.8	-10.9	-21.5	-14	-41.5
	NINV	440901	-2.1	-1	-7.2	13.8	2.4
	SCM	440901	15.6	25.2	35.4	20.4	136
North America	R10	-632470	-47.7	-221.2	223.8	43.9	-395.6
	R100	-632470	16	23.4	32.9	18.6	125.6
	NINV	-632470	46.2	65.5	66.6	34.7	442.8
	SCM	-632470	11.9	16.9	27.3	15.4	92.2
China	R10	194128	-761.9	167.3	94.2	23.4	-4338.3
	R100	194128	92.8	76.7	77.8	28	675.4
	NINV	194128	297.1	88.5	75.2	13	1382
	SCM	194128	0.1	8.9	17.6	23.4	58.2

Source: MAGNET simulation results.

7. Concluding remarks

If the existing global bank approach in the GTAP model is used in the recursively dynamic setting for long term projections, it may produce unrealistic investment growth and volatile movements in trade balances. As explained in the paper, this is due to the lack of an explicit connection between investment and savings at the regional level, in conjunction with a highly sensitive Armington trade structure governing trade flows between different model regions. The paper shows that only adjusting the rate of return response parameter or equalizing regional net investment growth rates under the existing global bank approach does not fix these issues, while some other traditional solutions including, for example, fixing trade balance movements or having trade movements targeting GDP, have to rely on additional assumptions and/or some kind of exogenous treatment of trade movements.

As a replacement of the existing global bank approach, we introduce in this paper segmented capital markets where regional investment and savings are explicitly connected via domestic/regional banks. With the new approach in place, the paper shows that the projected investment growth and trade balance developments become rather stable, along with the stable movements in the other macroeconomic indicators. As explained above, this is due to the fact that investment determination at the regional level is now able to take advantage of the stability offered on the savings side which is bound by a utility-elasticity-weighted Cobb-Douglass income allocation structure that has stability in nature. However, this kind of stability transmitted via the regional level connection between investment and savings may not be available in other CGE models including country level CGE models. In this sense, segmented capital markets can be a unique advantage available in a global model like GTAP in deriving stable solutions for longer term simulations.

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