Modeling Country Risk and Capital Flows in GTAP

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Abstract

This paper describes how the standard GTAP framework may be used to assess the short-run impacts of changes in international capital market conditions. It describes a technique that can be used to examine the short-run effects of changes in country risk. In the standard GTAP model investment demand is spread across regions according to a simple rate-of-return-equalizing rule. By making the risk premia in this rule explicit, we are able to examine the effects of changes in these risk premia. This work was originally developed as part of the course material for the South African GTAP short course in January 1998. South Africa has experienced a series of dramatic changes during the last decade, and these have had very significant effects on the capital account. Thus, this paper also contains an application of the technique developed to the recent South African experience, and an assessment of how well the simulated changes in this application match actual outcomes.

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1. *Introduction*

This paper describes how the standard GTAP framework may be used to assess the short-run impacts of changes in international capital market conditions. It describes a technique that can be used to examine the short-run effects of changes in country risk.

Treatment of capital market behavior is uncomplicated in the standard GTAP model. This treatment is described in Section 1. Investment demand is spread across regions according to a simple rate-of-return-equalizing rule. By making the risk premia in this rule explicit, we are able to examine the effects of changes in these risk premia. This is done in Section 2.

The standard GTAP model is comparative static. It does not capture the impact of investment on capital stocks. Because of this, the model is not useful for examining the dynamic, supply-side impacts of capital market developments. It is only able to capture the demand-side impacts of changes in investment patterns.

This work was originally developed as part of the course material for the South African GTAP short course in January 1998. South Africa has experienced a series of dramatic changes during the last decade, and these have had very significant effects on the capital account. Section 3 contains an application of the technique developed to the recent South African experience, and an assessment of how well the simulated changes in this application match actual outcomes.

1. *Treatment of Capital in the GTAP Model*

In the GTAP model, investors are represented by a single agent, known as the 'global bank'. This agent receives savings from households around the world, and invests these savings. Investment in each region is represented by purchase of a commodity called 'capital goods'. This commodity is akin to the 'investment' column of an input/output table rather than one of the productive sectors. Unlike GTAP's 'tradable commodities', it is a notional sector which does not undertake any real economic activity of its own (it does not employ any primary factors of production, and its value-added is therefore zero). The sector is used to assemble the various inputs to investment expenditure (e.g. construction services, machinery, etc.) into one composite commodity, which is then purchased by the global bank. In each region, both imports and domestic goods can be used as inputs into the sector. Because capital goods are not tradable, the amount produced in a country must be equal to, and is determined by, the amount demanded by the global bank in that country.

It is useful to separately consider two aspects of the capital goods sector in more detail: How total spending on capital goods is determined, and how this total is allocated across regions. These are discussed in turn.

Total Spending on Capital Goods

Saving is generally motivated by the prospect of future consumption, and likewise investment is generally motivated by the possibility of profits in the future. As GTAP is a comparative static model, it is unable to explicitly determine the future rewards to agents. Instead, savings behaviour is modeled as follows: The amount of saving enters the household's utility function directly (implicitly, current savings provide utility in the current period because they offer the promise of future consumption). In the default case, utility is modeled as a Cobb-Douglas function, which implies that a fixed proportion of total household income in each region is devoted to savings.

At a global level, saving and investment are equal in equilibrium. Because there is no transmission mechanism from capital markets to savings, the total level of investment is determined by the sum of savings in each region. It depends only on how incomes in each region change. This treatment does not capture the impacts of agents' rates of time preference or other factors which may influence decisions on levels of saving.

Allocation of Capital Spending Across Regions

The allocation of investment demand across regions is decided by the 'global bank'. The bank receives savings inflows from households in all regions, and given the size of these inflows, decides how best to invest its total funds across regions. It purchases real as opposed to financial assets.

As regards the decision-making process of the global bank, the GTAP model allows for the operation of either of two processes. Which of the two is operative depends on the value assigned to the *RORDELTA* parameter. The first, and simplest, process involves preserving the regional shares of global investment. In this case if total investment changes in a certain proportion, investment spending in each region will change in an identical proportion. This structure is somewhat limiting for present purposes, because it does not allow for any change in the relative attractiveness of different regions. It will not be discussed further herein.

The second process which the global bank may employ involves maximizing the rate of return on investment. For present purposes, this is a more suitable process, as it allows the bank to shift investment between regions as they become more or less attractive.

'Attractiveness' depends on expected future returns and risk. As mentioned above, GTAP does not explicitly look forward into the future, and so does not provide a robust basis for determining future returns, and how these may change. To provide a basis for this process, it is hypothesized that expected returns in a given region will fall as the amount of current investment rises.[1] The strength of this relationship depends on the value of the parameter *RORFLEX*.[2] Further, it is assumed that the initial distribution of investment represents an equilibrium not in the sense that actual rates of return are equalized across all regions, but in the sense that any differences between rates are accountable for by (unobserved) differences in riskiness.[3]

This means that the global bank, when faced with a change in the total amount of money it has to allocate across regions, or a change to the expected rate of return in any region, will adjust the allocation of investment in such a way that changes in risk adjusted rates of return across regions are equalized. This structure turns out to be amenable to explicitly incorporating a country risk premium.

2. *Modeling risk*

We assume that the global bank equalizes expected risk-adjusted rates of return, so that risk-adjusted rates for all regions are equal to some global average.

$$RORE(r) \,/\, RISK(r) = RORG$$

where, in accordance with GTAP notational convention, these capitalized variables represent levels, while lower-case variables represent percentage rates of change from initial levels.

- *RORE(r)* is a non-risk-adjusted expected rate of return, i.e. it is the expected rate of return in the absence of any default by the borrower.
- *RISK(r)* represents the ratio of equilibrium returns in region *r* to the global average rate of return. For relatively high-risk countries, this ratio will be above 1, and for relatively safe countries below 1. It is important to note that this variable represents a ratio rather than a certain number of basis points - it is better called a 'risk ratio' than a 'risk premium'.
- *RORG* does not represent a risk-free return but a weighted average of returns around the world. This formulation differs from the more familiar representation of required rate of return in a country being equal to the risk-free return plus some risk margin.

If we rewrite this as

$$RORE(r) = RORG * RISK(r)$$

then by total differentiation and division through by *RORE(r)* we can obtain

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[1] See Hertel and Tsigas (1997), pp54-60.

[2] The value of RORFLEX may vary across regions. It is set at 10 for all regions in the standard GTAP Model.

[3] In the standard database, no calibration procedure is used to ensure that this is the case. This has been done by e.g. Walmsley, 1998.

$$rore(r) = rorg + risk(r)$$

where these variables are percentage changes in their levels equivalents. This is the analogue of equation (11') in the standard GTAP model in the case where *RORDELTA* = 1:[4]

$$rore(r) = rorg + cgdslack(r)$$

This equation states that the percentage change in the rate of return on investment in region *r* is equal to the percentage change in the global rate of return plus a disequilibrium factor which is generally exogenous and set at zero in a general equilibrium closure. Normally, the *cgdslack* variable is only non-zero when we allow disequilibrium to exist in the market for capital goods. The main proposition of this paper is that *cgdslack* can be interpreted to represent a risk premium as defined above, although it was not originally designed for this purpose. In a general equilibrium closure, *cgdslack* is unused for any other purpose (being exogenous and unshocked), and therefore we do not disturb any other components of the model by using it in this way.

In the following sections, we continue to refer to *cgdslack* rather than *risk*, but interpret it as being equivalent to the percentage change in the variable *RISK* as defined above.

Implementation

There are two alternative closures that can be employed. Closure 1 is the standard GTAP closure, with *cgdslack* exogenous and *rore* endogenous for all regions. This closure can be used under certain conditions described below. Closure 2 involves 'swapping' these two variables for the region(s) of interest, so that *cgdslack* is endogenous for the region/s of interest and exogenous for all other regions, and *rore* is exogenous for the region/s of interest and endogenous for all others. No other 'swap' is required. In particular, the general equilibrium nature of the closure is preserved. Which of these two closures is more suitable depends on the experiment to be performed.

In either case, a shock will be imposed on the exogenous variable (*cgdslack* in Closure 1 or *rore* in Closure 2). For an historical simulation experiment (e.g., the South African application described in the following section), information must be available which allows the modeler to calculate an appropriate shock to the exogenous variable.

For Closure 1, it is necessary to have information on the pre- and post-shock values of the risk ratio in the region(s) of interest, or acceptable proxies thereof. Given that this risk ratio is not a widely-used concept, it may well be the case that such information is unavailable.

For Closure 2, in order to determine an appropriate shock for *rore(r)* it is necessary to know what the pre- and post-shock expected rates of return in the region(s) of interest are. For this closure, it is not necessary to know either the global required rate of return or the risk ratio. As noted above, the

[4] See Hertel and Tsigas, 1997, page 56.

expected rate of return excludes any possibility of default. A suitable proxy for this variable is more likely to be available (this is case for the South African application, where risk premia on DM-denominated bond issued by the South African government are used).

In a situation where the region of interest *(r)* is a small recipient of investment relative to the global total, we can assume that *cgdslack(r)* and *rore(r)* are approximately equal, because a change in *rore(r)* will have little impact on *rorg*. In this case, we can use Closure 1 even if we are not able to calculate an appropriate shock for *cgdslack*. The results will be approximately equivalent to those obtained from shocking *rore(r)* under Closure 2. In the South African experiment, the results obtained under both closures are very similar.

For a hypothetical experiment that does not involve replication of historical events, data availability is no longer the determining factor in which closure should be used. The modeler may legitimately impose a shock on either variable. If the modeler wishes to impose a shock on *cgdslack*, then Closure 1 should be employed.

In summary, Closure 1 can be used if *either* of the following two conditions are satisfied:

- a shock can be imposed on *cgdslack*, or

- the region of interest is small.

Otherwise, Closure 2 should be used, in which case it is necessary to adjust the set of exogenous variables specified in the command file. This 'swap' can be made for multiple regions. However, it cannot be made for all regions simultaneously, because this prevents any equilibrating adjustment in *rorg* from occurring, and no solution is possible.

Finally, since we wish to characterize the global bank as equalizing risk-adjusted rates of return across regions, *RORDELTA* must be set equal to one in the parameter file, regardless of the closure specified.

3. Application: South Africa in the 1990s

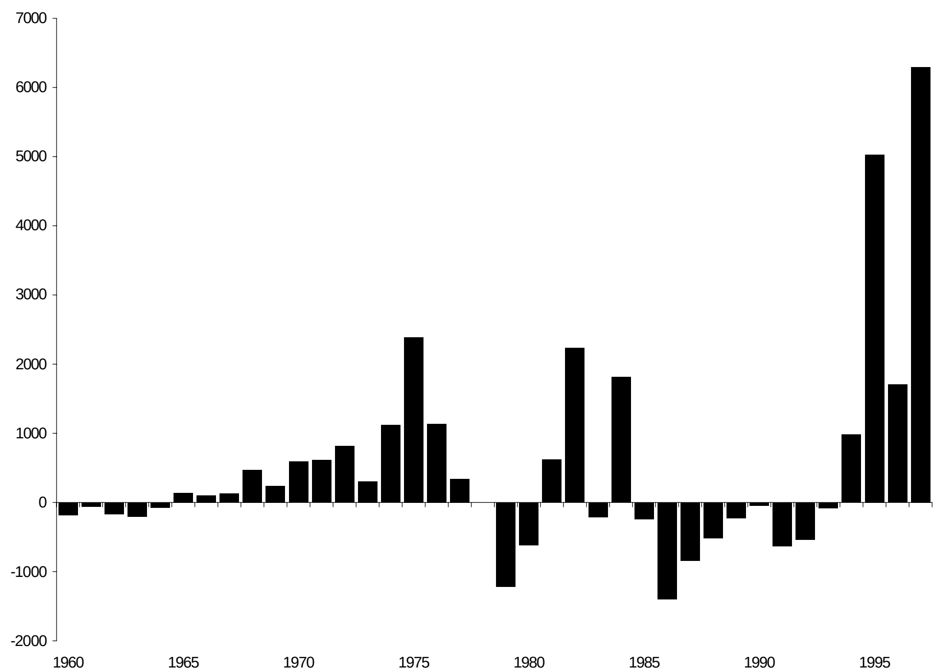
South Africa has undergone a great deal of political change during recent years. One result of this has been to affect the attractiveness of the investment climate. This section demonstrates how the technique described above can be used to simulate this historical experience.

Background

As a result of political changes and uncertainties, investors have shown fluctuating degrees of confidence in South Africa's prospects over the last few decades. Figure 1 shows South Africa's annual net international capital flows since 1960.

It can be seen that losses of investor confidence occurred in the early 1960s, the late 1970s and the period between 1985 and 1993. On each of these occasions, the loss of confidence stemmed from changes and uncertainties associated with the apartheid political system, and the implications of these for South Africa's current and future economic performance. In the period following World War II, existing segregation laws were strengthened and new ones promulgated, and the 'apartheid' system came into existence. Internationally, these met with disapproval, and South Africa was expelled from the Commonwealth in 1961. However, South Africa's most important trading partners, Britain and the US, generally resisted putting economic pressure on South Africa, so those sanctions which were imposed were of only limited effectiveness.

Figure 1: South Africa's net capital flows (nominal US$m)



Source: Reserve Bank of South Africa, http://www.resbank.co.za/Economics/hist.html, file "Balance of payments", Long-term capital movements.

Within South Africa, there were periodic episodes of large-scale overt civil unrest, notably at Sharpeville in 1960 and Soweto in 1976. Although these episodes were generally short-lived and geographically confined, they are likely to have had a substantial effect on investor confidence. Economic factors unrelated to political conditions in South Africa may have also contributed to these losses in confidence (particularly commodity price fluctuations) but it is clear that losses of confidence were at least partly due to political factors.

The loss of investor confidence since the mid-1980s was the result of a number of factors, internal (including strikes and civil unrest), and external (including trade boycotts and bans on direct investment). As well as having immediate effects on economic outcomes, these factors also portended an uncertain future for the South African economy. Stability and certainty are key factors in investment decision-making, and these were notably lacking from South Africa during this period. Between 1985 and 1993 South Africa experienced a steady outflow of capital. CREFSA (1996) discuss this 'pre-transition' period in more detail.

This situation ended in 1994 when a peaceful and apparently lasting solution to South Africa's political conflicts was found. This transition has had a number of effects on capital markets, including the following:

- negative impacts on the global operations of companies no longer occur as a result of investment in South Africa,
- a potential source of political instability has been removed,
- the economic outlook for South Africa has improved, and
- improved relations between South Africa and other African countries now provide investors in South Africa with more access to other African markets.

All of these have positive effects on investor confidence. Since 1994, credit rating assessments made by various agencies have become more favorable, and South Africa has enjoyed strong net capital inflows. It remains to be seen whether these will continue.

As well as this transition, the South African economy has been subject to many policy changes in the 1990s, including significant changes to financial market structure (these are discussed by CREFSA, 1996). Disentangling the specific effects of each change is problematic, and we aim only to assess the overall impact of changes in investor confidence. We focus only on the most recent shift in investor confidence, namely that occurring since 1994. We aim to demonstrate the use of the technique developed above, and to test how well this method is able to predict actual changes in capital flows.

Methodology

Because GTAP is purely a model of 'real' goods, with no financial instruments included, an ideal measure of returns would be based on the returns from directly holding real assets. In the absence of appropriate data, we are obliged to rely on data on returns to holding financial assets. Changes in rates of return on financial and real investments in a given country are likely to be strongly correlated, so a *change* in yield on financial assets may be an acceptable proxy for a *change* in yield on real assets, even though the absolute levels may differ.

CREFSA (1997) provide a succinct overview of the issues associated with interpreting the various yield data that are available. They consider yields on bonds to be more appropriate indicators of country risk than yields on syndicated loans, and identify three components of risk that may be manifested in bond yield premiums (over 'risk-free' alternatives):

- country risk,
- currency risk, and
- borrower-specific risk factors (if no government guarantee is involved).

Currency risk is a financial phenomenon that we wish to exclude from our measure of risk. South African debt that is denominated in Rand will include a currency risk premium, while South African debt that is denominated in the currency of the lender will not. Thus we prefer the latter. We also prefer to exclude borrower-specific risk factors from our measure, and we can do this by looking at data on government-issued or government-backed bonds.

Thus, yields on non-Rand denominated government bonds will give a reasonably good proxy for country risk.[5] CREFSA (1997) documents the risk premia that were achieved at the time of issue by non-Rand-denominated South African government bond issues between 1991 and 1997. Secondary market yields on these bonds would be useful supplementary data if available.

In order to compare yields, we need to determine the most appropriate 'pre-shock' and 'post-shock' points in time. Politically, the crux of South Africa's transition occurred in 1994, and the resulting capital market effects occurred immediately following this: In 1994 South Africa experienced a capital inflow for the first time since 1985, and received favorable ratings from various credit agencies. Although the size of the capital inflow was smaller than in subsequent years, it is clear that some effects of the transition were manifested in 1994. Thus comparison of yields before and after 1994 is appropriate (this does cause something of a problem in interpreting the results because the database is calibrated to 1995 – this will be discussed in the following section).

Of the bonds issued, those which seem most clearly to represent 'pre-shock' and 'post-shock' observations, and to be reasonably comparable in other respects (currency, size of issue and maturity) are the DM bond issues of September 1991 and September 1996.[6] The premia on these two issues were 240 and 140 basis points respectively (100 basis points = 1 percentage point). To calculate pre-

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[5]If capital markets are not able to clear, then actual yields may not accurately reflect risk premia. The fact that capital controls existed throughout this period in South Africa indicates that some caution is warranted in using this approach.

[6] The second of these, in fact, effectively refinanced the first.

and post-shock values for *RORE* we also need to know the 'risk-free' yield on DM-denominated debt, a suitable proxy for which is the yield on comparable-maturity bonds issued by the German government. We assume this to be 5%. We can calculate the necessary shock as follows:

$$rore(SAFRICA) = \frac{RORE^{1}(SAFRICA) - RORE(SAFRICA)}{RORE(SAFRICA)} * 100\% = \frac{(1.4 + 5.0) - (2.4 + 5.0)}{(2.4 + 5.0)} * 100\% = -13.5\%$$

We implement Closure 2 by exogenising and shocking *rore*(*SAFRICA*) by this amount. The variable *cgdslack*(*SAFRICA*) is endogenised, and adjusts to accommodate this change, reflecting the change in South Africa's risk ratio. No change to the risk ratio in other regions is assumed to occur, so no change to the closure for those regions is required.

To assess the validity of the hypothesis that *rore(r)* and *cgdslack(r)* are approximately equal for a small country, we also carry out an experiment using Closure 1, and imposes a shock on *cgdslack*("SAFRICA"). South Africa can be regarded as a small country, as it attracts only 0.4% of global investment according to the GTAP database.

The experiments use an aggregation of the version 4 pre-release GTAP database. (This is available in the ASA7x5 version subdirectory of the RunGTAP software on the GTAP web site. Complete instructions for replication may be found therein.) The set of aggregated regions include South Africa and its major trading partners:

- South Africa (SAFRICA)
- Rest of Southern Africa (RESTSAF)
- Rest of Sub-Saharan Africa (RESTSSH)
- European Union (EUNION) and
- Rest of the World (RESTWLD)

The set of aggregated commodities follows:

- Agriculture (AGRIC)
- Natural resources, extractive and related industries (EXTRACT)
- Food manufacture (FOOD)
- Unskilled labor intensive manufacturing (LITMNFC)
- Skilled labor intensive manufacturing (TECHMNFC)

- Capital intensive manufacturing (HVYMNFC) and
- Services (SVCES).

Results

In this section we examine how the shock affects capital markets in South Africa and elsewhere. The direct effects on rates of return in the two experiments are shown in Table 1. As hypothesized, the global rate of return is little affected by events in South Africa, so the results of the two experiments do not differ significantly.

Table 1: Capital market effects of experiments using alternative closures

	Closure 2	*Closure 1*
rore("SAFRICA")	**-13.50**	-13.41
cgdslack("SAFRICA")	-13.59	**-13.50**
rore("RESTWLD")	0.109	0.108
cgdslack("RESTWLD")	**0**	**0**
rorg	0.109	0.108

Note: Exogenous variables are in bold type.

Why do expected rates of return in other regions and the global rate of return all rise? The effect of the reduction in riskiness of investment in South Africa tends to increase investment in South Africa. As investment in other regions falls, expected returns in those regions rise. In the absence of any change in riskiness, we have

$$rore(r) = rorg$$

Thus the global rate of return also rises. The size of this effect depends on the extent to which investment is 'shifted' between regions. Thus, the smaller the country affected by a shock to risk, and the smaller the shock, the less will investment shift, and the less will *rorg* be affected

We next consider the effects on investment levels. Intuitively, the best starting point is provided by the experiment using the standard closure (Closure 1). What happens when the perceived risk of investing in South Africa falls? The immediate effect of a negative shock to *cgdslack("SAFRICA")* is to increase the risk-adjusted rate of return, i.e. the value of the ratio *RORE*("SAFRICA") / *RISK*("SAFRICA"). Equilibrium requires that this ratio remain (approximately) unchanged, and equal to the global average risk-adjusted rate of return *RORG*. To achieve this requires that the expected rate of return in South Africa, *RORE*("SAFRICA"), also fall. In the GTAP model, the expected rate of return is inversely related to the level of gross investment:[7]

[7] This is equation (58) in Hertel and Tsigas (1997).

$$rore(r) = rorc(r) - RORFLEX(r) \times [ke(r) - kb(r)]$$

The parameter *RORFLEX* determines the strength of this relationship.

Thus a reduction in the expected rate of return in South Africa must be matched by an increase in the amount of investment, and an increase in net capital inflows. Qualitatively this is just the result we would expect.

Quantitatively, we can compare the results of the experiment with actual outcomes. The variable we focus on is that shown in Figure 1, namely net long-term capital flows. The actual flows reported in Table 2 are averages for 1991-1993 (for the pre-shock figure) and 1995-1997 (for the post-shock figure). The equivalent value in the pre-shock GTAP database is reported in the second column of the Table.[8]

Table 2: Net capital inflow to South Africa (US$m)

	Actual	*Closure 2 experiment*
Pre-shock	-414	+5,772
Post-shock	+4340	+15,740

This table highlights a problem with this experiment. The database (which is also intended to represent a 'pre-shock' state of the world) is in fact calibrated to 1995, which is after the shock. In the absence of any modifications, this means that the shock is imposed upon the world as it was in that year. The practical effect of this in the present experiment is that the base-year database already shows the impact of the transition, and then another positive shock is imposed on top of this. This means that levels variables in the simulation results are not comparable with actual outcomes.

The best way to overcome this problem would be to use a database whose base year pre-dates 1994. With a base year of 1992, version 3 of the GTAP database is one such database, but it does not identify South Africa as a separate region. Another method is to recalibrate the model so that certain variables (in particular, South Africa's capital account position) better match the pre-1994 situation. Neither of these two methods are employed herein.

A third means of overcoming this problem is to do a 'backward shock', by imposing an opposite shock to that above. This means that we effectively simulate a move from the post-shock situation to the pre-

[8] These figures are calculated as follows:

$$I - S = \sum_{i = TRAD\_COMM} VDFA(i,CGDS) + \sum_{i = TRAD\_COMM} VIFA(i,CGDS,SAFRICA) - VDEP(SAFRICA) - SAVE(SAFRICA)$$

Table 3: Summary of experiments

	Closure 2	*Closure 1*	*Backward shock (Closure 2)*
rore(SAFRICA)	shock –13.5	endogenous	shock +15.6
cgdslack(SAFRICA)	endogenous	shock –13.5	endogenous

shock situation, rather than the reverse. This is straight-forward to implement and has no additional data requirements.[9] Table 3 summarizes the three experiments that were carried out.
Other than the features noted in the table, all experiments use the standard model (GTAP94de.TAB) and standard closure.

The results of this revised experiment for investment flows are reported in Table 4. Here, the actual post-1994 capital flow reported is that from 1995 only, as this is more directly comparable with the GTAP database. The remaining difference between 'post-1994' figures can be attributed to the fact that the data sources for the two figures are different. It is not related to the GTAP model or this experiment *per se*.

Table 4: Net capital inflow to South Africa under Backward Shock (US$m)

	Actual	*Backward Shock experiment*
Pre-1994	-414	-2783
Post-1994	+5,027	+5772

This experiment allows us to better compare the results with actual outcomes. How well does the experiment mirror the actual outcome? Qualitatively, the experiment correctly shows a change from a net capital outflow to a net capital inflow. Quantitatively, the actual net change in flows was US$5,441m, while the result of the experiment was a change of US$8,555m. We can expect a high degree of volatility in the results, because of the fact that net capital flows are calculated as the residuals of gross capital flows less depreciation. These gross flows are quite large relative to the net flows (depreciation, for example, is in the order of $20 billion). Therefore, we do not regard this degree of difference between the simulated and actual results as sufficiently large to reject the validity of the experiment.

The model parameter that most directly determines the impact of a change in the expected rate of return on the level of capital inflow is *RORFLEX*. The choice of a value for this parameter (usually set at 10) is somewhat arbitrary, as it has not been subject to empirical investigation. The higher is the value of *RORFLEX*, the less sensitive are capital flows to any change in the expected rate of return. The results above indicate that the simulated change in capital flows is larger than the actual change. If we consider the estimated shock and other aspects of the model and experiment to be accurate, then this suggests that the *RORFLEX* parameter is too low. A value of *RORFLEX* higher than 10 will result in a smaller change in capital flows.

[9] We need to recalculate the shock, because the denominator is now the pre-shock expected rate of return, i.e. 6.4%. The shock in this case is calculated as: $rore(SAFRICA) = \frac{(2.4+5.0)-(1.4+5.0)}{(1.4+5.0)} * 100\% = +15.6\%$

We can calibrate *RORFLEX(SAFRICA)* so that the experiment matches the actual change in capital flows (i.e. gives a net change of US$5,441m). Through a process of trial and error, this calibrated value of *RORFLEX(SAFRICA)* is found to be 14.9. However, it is not possible to formally determine whether this value is significantly different from its default vale of 10.

In addition to examining the relationship between rates of return and capital flows, the GTAP model is also well-suited to analyzing the effect of the latter on the rest of the economy. With regard to this particular experiment, Malcolm, Mwanawina and Arndt (1998)[10] found that the output of services sector expanded due to its substantial sales of inputs to investment, while the output of other sectors contracted. They also found that the shock had a significant negative impact on the level of investment in the rest of Southern Africa.

Conclusions

This paper describes how the standard GTAP framework may be used to assess the short-run impacts of developments in international capital markets. It proposes a method by which country risk can be incorporated into the existing model structure in a straightforward way, and provides a simple application of this method.

The results of the application are supportive of the validity of the approach, insofar as the simulated results match observed outcomes fairly well. The key parameter, *RORFLEX*, is also found to be set at approximately the correct level, at least for this experiment. This finding is rather weak, and could usefully be supported (or negated) by applications to other historical or contemporary instances of changes in country risk. One contemporary case of great interest (not examined herein) is that of the 'Asian 5', who have faced an opposite situation to that of South Africa.[11]

It remains to point out the fact that, while the GTAP model is well-suited for analysis of certain issues related to capital markets, there are also issues on which the model is silent, due to its static nature. GTAP can show how country risk affects capital flows, and it can show how capital flows affect demand (how the trade balance changes, how the pattern of domestic demand changes, etc.) but the standard model cannot show how capital flows affect supply. In the long run, the most important effects of capital flows are on the size of the capital stock and on productivity, which are not captured

[10] An electronic copy of this paper is available in the zip file which accompanies this technical paper on the GTAP web site.

[11] This has been done using a different model by McKibbin (1998). See also GTAP technical papers Nos. 7 and 9 by Francois, McDonald, and Nordstrom (1996) and Walmsley (1998), which propose long run closures in the model aimed at bringing in the supply side.

by the standard GTAP framework. The method described herein could usefully be incorporated into an augmented model framework designed to overcome this limitation.[12]

[12] For example, that of McDougall and Ianchovichina (1996).

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Appendix I: Alternative possibilities for modeling investment changes

Initially, three alternatives experiment designs were considered. The risk ratio method described above was chosen over the alternatives because it is a comparatively direct way of modeling the effect which we wish to analyse, and because it has the attractive property of preserving the GE nature of the model. The other two methods are described below.

1A. Trade balance shock

An increase in investment in South Africa without a corresponding increase in domestic savings requires an increase in the capital account surplus, and this must be matched by a corresponding increase in the trade account deficit (S – I = X – M). One means of imposing this outcome on the model is to make the trade balance *DTBAL* exogenous, and to shock this in a negative direction. This is an indirect method of achieving the effect that we wish to model.

However, *DTBAL* cannot be exogenised in a satisfactory way in the present case. Normally, if *DTBAL* is exogenised, either *saveslack* or *cgdslack* is endogenised. If *saveslack* is endogenised in this case, then any shock to the trade balance will be reflected in savings. This is not the effect which we wish to have occur.

If *cgdslack* is exogenised, then the shock will be reflected in investment. If this is done, however, the closure is no longer a GE one (*walraslack* is non-zero). This means that we also need to 'swap' *walraslack* and *PSAVE*, which in turn leaves us with no numeraire price. A different price can be fixed as the numeraire, but this requires that the market to which price pertains to fail to clear, which is not desirable. Overall this method, while not impossible to implement, has little to recommend it.

2A. Direct shock to investment

The most direct way to simulate an increase in capital inflow is to exogenise and positively shock the quantity of capital goods supplied *qcgds* in South Africa. To do this creates a similar problem to that encountered in implementing the trade balance method, however: When this is done, *walraslack* is non-zero. Consequently this also does not appear to be an attractive method.