Chapter 3

Behavioral and Entropy Parameters in the Dynamic GTAP Model

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1. Introduction

The dynamic theory in Chapter 2 describes various new parameters governing international capital mobility. This chapter examines what we can learn from country panel data about the magnitude of these additional parameters, corresponding calibration procedures, and the manipulation of the parameters with an aggregation program. The new parameter file containing parameters used in the dynamic theory is a GEMPACK header array file; its contents are as listed in Table 1.

The first new parameter, listed in Table 1, is INC. This parameter is the initial income level across simulations, and is used for calculating welfare measures in multi-period experiments. It has the units US$ millions. The rest of the parameters in Table 1 could be grouped according to their role in the model: lagged adjustment parameters, flexibility of gross rate of return, and parameters determining the allocation of regional wealth and composition of regional capital. These 3 parameter types are discussed in turn below.

2. Parameters determining lagged adjustments

2.1. Introduction

The investment theory presented in Chapter 2 is expressed in terms of gross rather than net rates of return. It allows only zero or positive gross rates of return (see, for example, equation (29) in Chapter 2 describing investors' understanding of the relationship

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between the level of capital stock and the rate of return). However, net of depreciation, rates of return may be negative, and they may decline to the negative of the depreciation rate. The long-run equilibrium in the GDyn model is defined as the convergence of the net rates of return to capital stock across regions. If region-specific risk premia are allowed, then the long-run equilibrium in the model is defined as the convergence of the risk-adjusted net rates of return to capital stock across regions. In the absence of risk premia, and if the depreciation rates are the same across regions, convergence of net rates of return guarantees convergence of gross rates of return. In this section, we construct cross-country time series data on net rates of return to capital to test the convergence hypothesis and determine the speed of convergence in rates of return across countries. The results are then used to set the lagged adjustment parameters in the model in accordance with the observed behavior.

2.2 Data

As in the standard GTAP model, the GDyn model is a real assets model; that is, there is no financial market. The gross rate of return to capital for each country is defined as the ratio of gross operating surplus to the capital stock, and the net rate of return to capital is the ratio of net (of depreciation) operating surplus to capital stock.[2] In order to determine parameters which will quantify the degree of capital mobility in the GDyn model, the rates of return to capital are constructed in accordance with these definitions.

Net rates of return to capital are often used to compare companies' profitability across countries. Walton (2000a, 2000b) uses the net rate of return to capital to compare profitability of the corporate non-financial sector in the UK with profitability in other

[2] In both definitions, the capital stock in the model is net capital stock.

countries. In these studies the rates of return were constructed using data available in the National Accounts of 19 countries. These rates of return are rather sparse for our purposes (the time period covered is too short for econometric investigation and the panel is unbalanced) and represent returns for non-financial corporations only, while rates of return to capital in the GDyn model represent overall profitability of the economy. So, these studies are considered here for illustrative purpose only.

There are two important features of the data highlighted in Walton (2000a, 2000b) that we should keep in mind when choosing data for our analysis. First, annual rates of return are calculated as the ratio of the operating surplus to capital employed. Profits, the main source of operating surplus, are defined fairly precisely and measured reasonably consistently. However, capital employed is not defined so precisely; definitions and the methods used to estimate capital stock vary from country to country. Most of the national statistics data on capital are compiled using the Perpetual Inventory Method (PIM) which is discussed in greater detail below. This method involves adding gross fixed capital formation to, and deducting consumption of fixed capital from, an initial estimate of capital stock. The variations come from the estimates of useful service lives by capital type and country, and are influenced by the business cycle and technological change. As a result, the differences between countries' rates of return, constructed using national accounts data, can reflect both differences in profitability and differences in calculation methods. Since countries have estimated profitability consistently over time, relative changes in net rates of return should reflect real changes in their economies and hence could be used in the cross-country profitability comparisons undertaken in Walton (2000a, 2000b). However, to test for convergence of rates of return to capital we need a capital stock series which are constructed using uniform (across countries) assumptions.

Second, not many countries have data available on profitability and/or capital stock, and time coverage varies from country to country (Walton (2000b)).

Our first step in constructing rates of return is to define profits associated with the use of capital stock. Using the income approach to gross domestic product, GDP can be represented as a sum of value added at factor costs plus indirect taxes. The value added at factor costs consists of labor earnings, capital earnings and land earnings. While time series data on value added at factor costs with good country coverage is available from many sources (for example, the World Development Indicators (WDI) database supported by World Bank), the labor earnings data is problematic. For this reason, the analysis is started with a set of countries for which these data are most readily available – the Organization for Economic Cooperation and Development (OECD) countries.

Time series data on gross operating surplus at current prices are obtained from the SourceOECD database, Annual National Accounts Volume II - Detailed Tables - Main Aggregates Volume 2004 release 01 (SourceOECD). This database covers detailed national accounts data for most OECD countries, including components of value added. It covers the period from 1970 to the present. The SourceOECD database lists four components of GDP: 1) compensation of employees, 2) taxes less subsidies on production and imports, 3) gross operating surplus and gross mixed income, and 4) a statistical discrepancy, which is small or zero for most of the countries considered. The sum of gross operating surplus and gross mixed income is used as a proxy for capital earnings. Note that this measure overestimates capital earnings because it includes land earnings, returns to natural resources, and that portion of self employed labor earnings that is not accounted for by imputed wages. Land earnings should not be a big problem because they are expected to be small relative to capital earnings in developed countries.

However, potential inclusion of self employed labor may lead to a larger error in the capital earnings measure. But it is expected that this error is much smaller in the OECD than for developing countries. The gross operating surplus measure also includes depreciation of capital stocks. As noted before, the convergence in GDyn is modeled as convergence in net rates of return. To test for convergence of net rates of return, net operating surplus measures will be constructed.

The second step in constructing rates of return to capital is to define capital stocks. Several alternative sources for capital stock data for the OECD countries could be used. In all these sources the capital stock estimates are derived using the perpetual inventory method (PIM). The first data source for capital stock data for the OECD countries is the OECD itself. Until 1997, OECD published annual data in a report titled "Flows and Stocks of Fixed Capital" (Statistics Directorate OECD, various years).[3] However, in 1997, production of these data ceased as countries moved to the new system of national accounts. Some countries are now starting to produce these data again, but not enough for the OECD to resume publishing the data. The data are available for only a few of the OECD countries and cover different time periods for different countries. The data come from National Accounts statistics, and as noted before, the assumptions made to construct these series differ from country to country.

A second data source is Larson *et al*. (2000) who constructed capital stock time series data for 62 industrial and developing countries for the period 1967-1992. The main objective of this database was to provide sectoral and economy-wide capital stock data for countries both within and outside of the OECD. A common method was used in the calculations to facilitate comparisons across countries. Larson *et al.* (2000) constructed

[3] The PIM and the estimation procedures used by the OECD countries are described in the manual issued by OECD (OECD, 1993).

fixed-capital series based on national account investment data, using a modified version of the PIM. A third data source for capital stock data is Nehru and Dhareshwar (1993) where capital stock time series are constructed for 92 developing and industrial countries from 1960 to 1990.

Since the OECD capital stock data are sparse and constructed using assumptions which differ from country to country, this source is eliminated from consideration and a choice is made between Larson *et al.* (2000) and Nehru and Dhareshwar (1993) databases. The PIM used in the construction of these databases can be generalized in the following equation:

$$K_t = s_t I_t + s_{t-1} I_{t-1} + \ldots\ldots + s_{t-L} I_{t-L}, \quad (1)$$

where K_t is capital stock at the end of year t, I_t is investment made during year t, L is lifetime of capital good, $t-L$ is the vintage of the oldest surviving capital asset, and s_j is the productivity of investment of age j, $0 < s_j < 1$ for $0 < j < L$; $s_0 = 1$ and $s_j = 0$ for $j \geq L$. The main difference between the Larson *et al.* (2000) and Nehru and Dhareshwar (1993) methods for constructing the databases is in the assumptions made about the path of s_j. Nehru and Dhareshwar (1993) assume that s_j follows a geometric decay pattern with rate of decay fixed at 4%, which is equivalent to the assumption of infinite lifetime L of capital assets and 4% decline in productivity every year. The method used to define productivity in Larson *et al.* (2000) is more general and closer to the one used in the OECD data. This method assumes finite lifetime L of capital assets, and a curvature parameter β bounded from above by 1 in order to restrict productivity to be non-negative (Larson *et al.*, 2000):

$$s_j = (L-j)/(L-\beta j),\ 0 \geq j \geq L \quad (2)$$

To generate economy-wide capital stocks from investment data, Larson *et al*. (2000) set β=0.7, and defined service life L as a stochastic variable with mean 20 and standard deviation of 8 years. Analysis of expression (2) shows that productivity falls with the age of assets, and when β is positive but less than unity, the depreciation accelerates with time of asset use. Figure 1 illustrates these points and the differences in productivity paths assumed in Nehru and Dhareshwar (1993) and Larson *et al*. (2000).

To construct a capital stock series, an assumption about the initial value of capital is needed. Many techniques to seed the initial values are discussed in Nehru and Dhareshwar (1993) and Larson *et al*. (2000). However, if the investment series are sufficiently long, and given that the productivity of old capital is low, contribution of old capital to the current capital stock should be small. This view is supported by the analysis of sensitivity of constructed capital stock series with respect to the choice of initial values in Larson *et al*. (2000).

Because the Larson *et al*. (2000) assumptions to measure economy-wide capital stocks are more realistic, and capital stock series constructed using Larson *et al*. (2000) method are less sensitive to the choice of initial value, this database is chosen to construct rates of return to capital. The choice of countries and years to be included in the analysis is dictated by the availability of data in both the OECD records on gross operating surplus and the capital stock data in the Larson *et al*. (2000) database. To construct net operating surplus, depreciation should be subtracted from the gross operating surplus. Data on depreciation are available from SourceOECD, however these data are not consistent with the depreciation assumed in calculations of net capital stocks in Larson *et al*. (2000). To calculate net operating surplus which is consistent with the net capital stock data, the depreciation D_t is recovered from the Larson *et al*. (2000) time series using formula:

$$D_t = K_{t-1} - K_t + I_t \tag{3}$$

and then subtracted from gross operating surplus.[4] To calculate the values of depreciation (D_t), current capital (K_t), investment (I_t) and capital in the previous year (K_{t-1}) should be measured in constant prices. The capital stock data in Larson *et al*. (2000) are given in 1990 US$, while investments are given in 1990 local currency (LCU). A real exchange rate $e_t = 1/E_t\,(p_t^{US}/p_t)$ is constructed, where E_t is nominal exchange rate in US$ to local currency, p_t^{US} is the dollar deflator and p_t is the domestic deflator.[5] Using the real exchange rate, capital stocks are converted from 1990 US$ to 1990 LCU and depreciation in 1990 LCU is calculated. Using the dollar deflator, capital stock and depreciation were converted into current US dollars. Gross operating surplus is also converted from current local currency to current dollars using SourceOECD exchange rates.[6] Net operating surplus in current dollars is calculated by subtracting depreciation from gross operating surplus, and then the net rates of return are calculated as a ratio of net operating surplus and net capital stock for 20 OECD countries from 1970 to 1992.[7] The net rates of return series are shown in Figure 2. To make the figure clear, the rates of return are shown only for 9 OECD countries. The time series of the other 11 countries are in the range between rates of return in Portugal and Finland. The rates of return are very high in the beginning

[4] For some reason, the calculated depreciation in 1980 is negative for all countries in the Larson *et al*. (2000) data base. For each country, we use arithmetic average of 1979 and 1981 depreciations for the 1980 depreciation.
[5] Investments series and all determinants of the real exchange rate are given in Larson *et al*. (2000), including the exchange rate, which is the market exchange rate from the International Monetary Fund.
[6] For European countries adopting the Euro, the SourceOECD data base lists gross operating surplus in Euros. For this reason, SourceOECD exchange rates of US dollar to local currency are different from ones obtained from the International Monetary Fund.
[7] These countries are Australia, Austria, Belgium-Luxemburg, Canada, Denmark, Finland, France, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, South Korea, Sweden, Turkey, United Kingdom, and the United States.

of the sample in Turkey, Greece, South Korea and Portugal, but then decrease. This feature concurs with our expectations that the rates of return to capital are higher in the least developed countries since capital is a scarce resource. As these countries grow, capital expands and its marginal product falls, the rates of return to capital decline. Note that in Finland in 1991, the return to capital is negative, though small in absolute magnitude. This may be because the Larson *et al*. (2000) method overestimates the depreciation, or, possibly simply due to a decline in capital earnings.

2.3 Convergence of Rates of Return to Capital

Convergence of different productivity measures is a popular topic (Bernard and Jones (1996a), Bernard and Jones (1996b), Nin *et al*. (2004)). This section draws on the econometric techniques utilized in these studies to focus on the question of convergence in rates of return. Assuming the absence of risk premia, the long-run equilibrium in the GDyn model is defined as the convergence of the ratios of capital earnings to capital stock across regions. Thus an important research question is: Do these measures actually converge? An initial look at the dispersion of the rates of return to capital across countries in Figure 2 shows that the dispersion does appear to decline over time. Time series evidence can also be used to examine the convergence of the rates of return applying the test for unit roots in panel data. With such a short time series, unit root testing for pairs of countries would appear to be out of the question; however the technique of testing unit roots in panel data would be appropriate (Levin and Lin (1992), Bernard and Jones (1996b)).

In conducting the unit root test, the United Kingdom is chosen as a benchmark country and deviations from the United Kingdom's rate of return for 19 OECD countries are constructed. Consider the following general model:

$$rr_{it} = \mu_i + \rho \cdot rr_{it-1} + \varepsilon_{it} \tag{4}$$

where the rr_{it} is the difference between country i and the benchmark country rates of return, with error term $\varepsilon_{it} \sim$ iid $(0, \sigma_\varepsilon^2)$, and drift $\mu_i \sim$ iid$(\bar{\mu}, \sigma_\mu^2)$. Let $\hat{\rho}$ and t be the OLS parameter estimate and t-statistic from the regression above, respectively. Bernard and Jones (1996b) show that under the null hypothesis of a unit root and nonzero drift, t approaches the standard normal distribution. We are testing the null hypothesis of no convergence, which is defined to mean that the deviation of the rate of return to capital from a benchmark country is a non-stationary process with nonzero drift. The alternative hypothesis is that rates of return to capital are converging in the sense that deviations of rates of return to capital from the benchmark country across countries are stationary processes. Table 2 reports estimates of country specific drifts μ_i together with result of the test $\hat{\rho}=1$. The results show that $\hat{\rho}$ is significantly less than 1 providing evidence against the null hypothesis of no convergence. Because all considered countries are developed countries, this result is expected and similar to what was found in the literature on convergence of productivity for OECD countries (Bernard and Jones, 1996b). The estimate of $\hat{\rho}$ reported in Table 2 implies a convergence rate of 9% per year for the net rates of return to capital in the OECD countries.

It is also important to mention that model (4) allows for country specific intercepts. For 16 of the 19 (without benchmark) countries, the intercepts are not statistically different from zero. This result has implications for the target rate and closure in the dynamic model: if depreciation rates are assumed to be equal, a common target rate can be set in the initial data base for 17 (16 plus United Kingdom) countries. For 3 other countries – Turkey, Ireland and Greece – the intercept is different from zero. One possible interpretation is that, even if the deviations from the benchmark are stationary, there is a non-zero long-run value of the deviation, which may, in turn, suggest country-specific target rates for these 3 countries in the GDyn. Another possible explanation is that we have too few data points to observe complete convergence, or zero long-run deviation from benchmark, for these countries.

2.4. Calibration of Lagged Adjustment Parameters

The degree of capital mobility is defined as the speed with which differences in the risk-adjusted rates of return across regions are eliminated. Low speeds of convergence imply smaller changes in capital flows and slower capital reallocation. The time series analysis of the convergence of rates of returns in the previous section can be used to calibrate parameters in the model to mimic the degree of capital mobility observed in the data. In this section we describe the calibration procedure.

The disequilibrium mechanism determining the regional supply of investments and the path of capital stocks in the model consists of three lagged adjustments: 1) adjustment of the expected rate of return toward actual rate of return, 2) adjustment of the expected rate of return toward target rate of return, and 3) adjustment of perceived by investors normal growth in capital stock toward actual normal growth rate. The speed of each adjustment depends on the corresponding parameter: *LAMBRORGE*, *LAMBRORG* and *LAMBKHAT* (Table 1). The higher the magnitude of these parameters, the faster is the adjustment process toward equilibrium in the model. In the short and medium run, larger *LAMBRORG* leads to larger changes in the required rate of growth in the rate of return, larger *LAMBRORGE* leads to larger changes in the expected rate of return, and larger *LAMBKHAT* leads to larger changes in the perceived by investors normal rate of growth in capital stocks *KHAT* . As a result, larger magnitudes for any of the adjustment parameters are reflected in more volatile investments, capital and GDP. In the long run the differences between the target and expected rate of return disappear, the expected and actual rates of return converge, and *KHAT* is equal to actual growth in capital stock; so, in the long run the magnitudes of the lagged adjustment parameters do not matter.[8]

While the first two adjustment mechanisms are introduced into the model to reflect investor's behavior, the third mechanism is built in for convenience and may be viewed as a substitute for calibration. Consider a specific scenario wherein we know that in the long run the normal rate of growth in capital stocks is zero. In such situations we can turn off the mechanism permitting adjustment of investors' perceived normal growth in capital stock toward the actual normal growth rate and set the initial *KHAT* to zero.

Ianchovichina (1998, p.80) considered the stability properties of the GDyn model and found that the lower the magnitude of the parameter *LAMBKHAT*, the higher the length of run over which the model is stable. Since the role of the parameter *LAMBKHAT* is different from the parameters *LAMBRORGE* and *LAMBRORG*, and because higher magnitudes of *LAMBKHAT* may affect the stability of the model, we set *LAMBKHAT* to some small number and manipulate *LAMBRORGE* and *LAMBRORG* to achieve desired speed of convergence.

In the following example, based on a 3x3 aggregation of the GTAP 5.4 Data Base (Dimaranan and McDougall, 2002) we show how we calibrate parameters to achieve the desired degree of capital mobility in the model. In this aggregation there are three regions

[8] In the long run equilibrium, the *perceived* by investor normal growth rate in capital stock *KHAT* is equal to *actual* normal growth rate and equal to actual growth in capital stock $qk(r)$.

(North America (NAM), Europe Union (EUN) and the rest of the world (ROW)) and three sectors (food, manufacturing and services). Initially we set *LAMBRORG* and *LAMBRORGE* to 0.4 and *LAMBKHAT* to 0.2.[9] Parameters *LAMBRORGE* and *LAMBRORG* are set equal because they determine speeds of similar adjustments in the model − convergence of expected rate to target rate of return, and convergence of expected rate to actual rate of return. In the case of no risk premiums and uniform across regions depreciation rate, net rates of return to capital converge to the (net of depreciation) target rate. The convergence of net rates of return is shown in Figure 3.

To determine the speed of convergence in this simulation, we estimate equation (4) using simulated net rates of return over 22 years. We define ROW as the benchmark country and define $rr_{NAM\,t}$ as difference between rates of return in NAM and ROW and $rr_{EUN\,t}$ as difference between the rates of return in EUN and ROW. We estimate equation (4) in deviations of rates of return from the benchmark country. The estimated speed of convergence is 6% per year. To achieve a greater degree of capital mobility we gradually increase *LAMBRORG* and *LAMBRORGE*, keeping them equal. It is important to keep in mind that the expected rates of return in the initial data base are a function of the parameter *LAMBRORG*. For every new value of *LAMBRORG* we recalculate expected rates of return in the initial data base. For this specific aggregation, with *LAMBRORG* and *LAMBRORGE* set to 0.5, we achieve the speed of convergence, found previously in section 2.3, of 9%. The corresponding convergence of the rates of return obtained from the GDyn simulation is shown on Figure 4. In this example we used 3x3 aggregation of GTAP Data Base. To achieve desired 9% in 7x7 aggregations, *LAMBRORG* and

[9] We keep *LAMBKHAT* at 0.2 in the subsequent simulations for the reasons discussed above.

LAMBRORGE were set to 0.4. Thus, to achieve desired speed of convergence for every new aggregation, the test (4) should be repeated.

It is also important to keep in mind that the convergence rate of 9% per year was obtained using OECD data only. Most likely, the speed of convergence would be lower if we included countries outside OECD and hence a speed of convergence of 9% per year represents the upper bound of the desirable convergence of the net rates of return in the GDyn model. Without estimating equation (4) on data which includes countries outside OECD, we cannot say anything about the lower bound. Since the GTAP Data Base includes all countries, a speed of convergence of 9% overestimates the degree of capital mobility and some lower value is probably more desirable. The lower speed of convergence is also desirable because for some aggregations of the GTAP Data Base high values of *LAMBRORG* and *LAMBRORGE* may lead to the model being insolvable.

Finally, let us consider situations when a low value of *LAMBRORGE* is desirable. Consider the situation when a region is characterized by a very large expected rate of return and a very low actual rate; such that the error in investors' expectations is large. Large errors in investors' expectations leads to a large decline in the expected rate of return *rorge*(*r*), determined by the following expression in the model (equation 39 in Chapter 2):

$$\begin{aligned} rorge(r) = &- RORGFLEX(r) \times [qk(r) - 100.0 \times KHAT(r) \times time] \\ &- 100.0 \times LAMBRORGE(r) \times ERRRORG(r) \times time + srorge(r) \end{aligned}$$

where *ERRRORG*(*r*) = *ln*(*RORGEXP*(*r*)/*RORGROSS*(*r*)) is an error in investors' expectations. Note, that contribution of the error to the change in the expected rate of return depends on the magnitude of the parameter *LAMBRORGE*: the larger the parameter, the greater the contribution of the error to *rorge*(*r*).

The large decline in the expected rate of return, in turn, leads to a large positive change in the required rate of growth in the rate of return and, since required and expected rates of growth are equal, it also lead to a large positive change in the expected rate of growth in the rate of return (equation 35 in Chapter 2):

$$erg\_rorg(r) = LAMBRORG(r)*(rorgt(r) - rorge(r)).$$

This large positive change in the expected rate of growth in the rate of return determines the change in investment *qcgds*(*r*) through equation (33) in Chapter 2:

$$erg\_rorg(r) = -RORGFLEX(r)*\{IKRATIO(r)*[qcgds(r) - qk(r)] - DKHAT(r)\}$$

To achieve large positive change in the rate of growth in the rate of return, investors should reduce their investment. The larger the change in the rate of growth in the rate of return to capital *erg_rorg*(*r*), the larger the reduction in investment should be undertaken. In some cases, the required decline in investment is so large, that the *level* of investment may become negative, which is not allowed in the model simply because we do not observe such cases in real world.

The following example based on a 7x7 aggregation of the GTAP 5.4 Data Base illustrates this case. In this aggregation Japan is a separate region and is characterized by a large error in investors' expectations. This large error in investors' expectations about rates of return to capital in Japan leads to a large decline in the expected rate of return, positive change in the expected rate of growth in rate of return and large decline in investment. In the second year of the simulation the decline in investment is so large, that one of the inputs in production of capital goods in Japan becomes negative. This is equivalent to destroying capital stock. Since we do not allow such situations – spending on investment is restricted to be nonnegative – the model cannot be solved.

As it was noted before, the contribution of the error to the change in the expected rate of return depends on the magnitude of the parameter *LAMBRORGE*. In this example, the *LAMBRORGE* was initially set to 0.4. By decreasing *LAMBRORGE*, we can reduce influence of the error in investors' expectations on *rorge*(*r*), *erg_rorg*(*r*) and then, finally, on *qcgds*(*r*). At *LAMBRORGE* set to 0.2 for Japan, the investment declines much more slowly and the situation where the level of input in production of capital goods becomes negative is avoided. While the lower value of *LAMBRORGE* for Japan allows avoiding negative level of investment, it creates asymmetry in a sense that the degree of capital mobility for Japan in this simulation is lower than for other regions. In situations where such asymmetry is not desirable, *LAMBRORGE* could be set to the smaller value of 0.2 in our example, uniformly across regions. A better solution would be to set some exogenous minimum level of gross investment, and then let investors to choose the maximum of this minimum investment level and investment determined by the dynamic theory (see Appendix A).

3 Elasticity of rate of return to capital with respect to capital stock

The parameter *RORGLEX* in Table 1 represents the negative of the elasticity of the expected rate of return with respect to the size of capital stock. The effect of different values of *RORGFLEX* on the expected rate of return schedule is shown in Figure 5.
A large value for *RORGFLEX*, for example 10, implies that a 1% increase in the capital stock is expected to reduce the rate of return to capital by 10%; hence, the expected rate of return is sensitive to the supply of capital goods. Inversely, the supply of new capital goods is not very sensitive to the changes in the expected rate of return.

Using a production function approach to GDP, it can be shown that *RORGFLEX* is the inverse of the elasticity of substitution between labor and capital in a constant elasticity of substitution (CES) production function. The following example illustrates this point. If we produce GDP via a CES production function where capital and labor are the sole inputs, we can write:

$$Y = (\alpha K^{-\rho} + (1-\alpha)L^{-\rho})^{-1/\rho} \tag{5}$$

If we maximize profits defined as $\Pi = pY - wL - rK$, the first order conditions (FOC) are:

$$\alpha\left[\frac{Y}{K}\right]^{1+\rho} = r/p \tag{6}$$

$$(1-\alpha)\left[\frac{Y}{L}\right]^{1+\rho} = w/p$$

where *r* is rental price of capital, *w* is labor wage, *p* is price level, and factor rental rates are *r/p* and *w/p* for capital and labor, respectively. Taking logarithms of the FOC we get:

$$\ln\alpha + (1+\rho)\ln\frac{Y}{K} = \ln(\frac{r}{p}) \tag{7}$$

$$\ln(1-\alpha) + (1+\rho)\ln\frac{Y}{L} = \ln(\frac{w}{p})$$

From FOC, the negative of the elasticity of the return to capital with respect to the size of capital stock, *RORGFLEX*, is:

$$RORGFLEX = -\frac{d\ln(r/p)}{d\ln K} = 1+\rho = 1/\sigma \tag{8}$$

where *σ* is the elasticity of factor substitution of a CES production function. Expression (8) for *RORGFLEX* is derived under the assumption that the price of capital goods is equal to the GDP price index *p*. This assumption allows defining the rate of return to capital as *r/p*. Note, that the rate of return to capital in (8) is actual, not expected, rate of return to capital. Here and further we assume that investors' understanding of the relationship between *actual* rate of return and size of the capital stock and relationship between *expected* rate of return and size of the capital stock are characterized by the same magnitude of the curvature parameter *RORGFLEX*. This assumption is reasonable since it simply implies that investors know the economy's production possibility and build their expectations in accordance with these possibilities.

Having data on inputs and prices, we could obtain the elasticity of factor substitution − and hence the parameter *RORGFLEX* −could be obtained from joint estimation of FOCs (7) and the production function (5). However, the production structure in the GTAP model is much more complex than the simple CES production function approach described here. Instead of econometric estimation, we discuss two approaches to setting *RORGFLEX*. The first approach allows us to obtain model consistent or the perceived (by investors in the model) elasticity of the rate of return with respect to the size of capital stock. This approach is based on a post-aggregation calibration procedure for each region each time a new aggregation is made. In this calibration simulation we shock the capital stock in each region by shocking the exogenous shift variable *sqk*(*r*), region-specific shock to capital stock. Then the elasticity, given in (8), is calculated as the ratio of the obtained percent change in the actual rate of return *rorga*(*r*) and capital stock *qk*(*r*). This simulation is conducted in a comparative static mode, that is the variable *time* is not shocked and all parts of the model which depend on the variable *time* are excluded. As a result, the obtained change in the rate of return is not conditional on the parameter *LAMBRORGE*, which is desirable since *LAMBRORGE* is not accurately known.

It should be noted that calibrated *RORGFLEX* is conditional on the model structure, the data base and parameters. As a consequence, the true elasticity of the rate of return in the initial period, computed with the initial data base, becomes inconsistent in the later periods of the simulation as we update the data base. Ideally, *RORGFLEX* should be recalibrated every period, but this would tremendously complicate the use of the model. However, since the full model uses CES production functions, and the elasticities of substitution in these production functions are constant, we expect that the changes in the true elasticity will be relatively minor. If so, *RORGFLEX* can be calibrated just once before simulation, but on post-aggregation data base. The setting of *RORGFLEX* can be further simplified noting that in many experiments with the model the calibrated elasticity was close to 1 for all considered regions (see for example, Ianchovichina, 1998). Hence, *RORGFLEX* can be set to 1 uniformly for all regions independent of the aggregation.

The second approach determines the *RORGFLEX* parameter not by post-aggregation calibration, but by applying simple aggregation formulas (see below). This approach is consistent with the view that different economies are characterized by different elasticities of the rate of return to capital with respect to capital stock, and would require decision about the magnitude of *RORGFLEX* in each country/region. Note that the decision may be purely judgmental, or based on the calibration of *RORGFLEX* parameters once for all disaggregated regions in the GTAP Data Base and then aggregated for specific scenarios. Magnitudes of *RORGFLEX* obtained with this approach are unlikely to match exactly with the model consistent values of *RORGFLEX*.

When *RORGFLEX* diverges from the true flexibility of the capital stock, the divergences affect the behavior of the model in several ways. Consider two situations: first when *RORGFLEX* is set to the model consistent value as described by the first approach, and second when *RORGFLEX* is set to some different value. The differences between the second and first situations are errors due to inconsistent value of

RORGFLEX.[10] Comparing these two situations, first there is an error in the change in the expected rate of growth in the rate of return (equation (33) in Chapter 2):

$$erg\_rorg(r) = -RORGFLEX(r)*\{IKRATIO(r)*[qcgds(r) - qk(r)] - DKHAT(r)\}$$

However, it is not troublesome. This equation determines the change in real investment *qcgds*(*r*) in a region. Since expected and required growth in the rate of return are equal, the expected rate of growth in the rate of return is (equation 35 in Chapter 2):

$$erg\_rorg(r) = LAMBRORG(r)*(rorgt(r) - rorge(r)),$$

and the change in investment *qcgds*(*r*) is given implicitly:

$$-RORGFLEX(r)*\{IKRATIO(r)*[qcgds(r) - qk(r)] - DKHAT(r)\}$$
$$= LAMBRORG(r)*(rorgt(r) - rorge(r)) \qquad (9)$$

For different values of *RORGFLEX*, the same *qcgds*(*r*) can be obtained by simply changing parameter *LAMBRORG* in expression (9). That is, the inconsistency in *RORGFLEX* can be eliminated by adjustment in the parameter *LAMBRORG*. Although we don't do this, we could adjust the parameter *LAMBRORG* since it is not accurately known.

Returning to the comparison of the two situations − model consistent and model inconsistent elasticity of rate of return with respect to the size of capital stock − there is an error due to model inconsistent value of *RORGFLEX* in the adjustment of *DKHAT* (equation 42 in Chapter 2):

$$DKHAT(r) = LAMBKHAT(r)*[\ RORGFLEX(r)^{-1}*rorga(r)\ qk(r)$$
$$-\ 100*KHAT(r)*time].$$

[10] In this discussion, the errors are different from "errors in investors' expectations" in the structure of the dynamic model.

Provided that the rate of return does not change rapidly (*rorga*(*r*) is small), this error is small. Over the long run, the rate of return is unlikely to change rapidly, so this error is unlikely to interfere greatly with the elimination of errors in the perceived normal rate of growth in the capital stock. Finally, there is an error in the equation for the expected rate of return, in the term representing adjustment of the expected rate of return to abnormal growth in the capital stock:

$$\begin{aligned} rorge(r) = &- RORGFLEX(r) \times [qk(r) - 100.0 \times KHAT(r) \times time] \\ &- 100.0 \times LAMBRORGE(r) \times ERRRORG(r) \times time + srorge(r) \end{aligned}$$

Again, over the long run the error is likely to be small, since there is unlikely to be prolonged rapid abnormal growth in the capital stock.

It seems then that errors in *RORGFLEX* may not interfere greatly with the convergence properties of the model. On the other hand, they will affect the behavior of the model when the economy is far from equilibrium: when there is rapid abnormal capital accumulation, or when the rate of return is changing rapidly. The consequences of errors in *RORGFLEX* are not clear a priori, and the behavior of the model should be tested under realistic scenarios, with various treatments of *RORGFLEX*. As an illustration of possible problem encountered, we use the 3x3 aggregation, discussed above. For three regions in this aggregation – NAM, EUN and ROW – the post-aggregation calibrated *RORGFLEX* is close to one. However, for illustration purposes, we set *RORGFLEX* = 5 for three regions.[11] Figure 6 shows that when the elasticity of the rate of return is set much larger than its model consistent value, rates of return to capital diverge. So the setting of this parameter requires some care.

[11] The expected rates of return in the initial data base are a function of the parameter *RORGFLEX*. In this experiment the expected rates of return in the initial data base are consistent with the new *RORGFLEX* = 5, as required by the investment theory described in Chapter 2.

If the second approach is adopted, that is *RORGFLEX* parameters are not determined by post-aggregation calibration, and if countries in a region are characterized by different elasticity of the rate of return to capital with respect to capital stock, then the issue of how to aggregate *RORGFLEX* across countries arises. The aggregation method is described in the Chapter 4.

4. Parameters determining composition of wealth and capital in a region

4.1. Introduction

The investment theory of GDyn determines how much will be invested in any given region each period. These regional investments include both domestic investment and foreign investment via the global trust. How regional savings are allocated between investments in domestic and foreign assets in the model is described in Chapter 2. To remind the reader, equity in region's firms $WQ\_FIRM(r)$ has two components: equity owned domestically ($WQHFIRM(r)$) and equity owned by foreigners ($WQTFIRM(r)$), where:

$$WQ\_FIRM(r) = WQHFIRM(r) + WQTFIRM(r) \tag{15}$$

The value of financial claims held by a regional household $WQHHLD(r)$, or regional wealth, has also two components: ownership of foreign equity or equity of regional household in the global trust ($WQHTRUST(r)$), and ownership of domestic equity ($WQHFIRM(r)$), where

$$WQHHLD(r) = WQHFIRM(r) + WQHTRUST(r). \tag{16}$$

Thus, for each region we have two accounting identities, but three unknowns. Equations (15) and (16) determine net foreign assets, but not gross foreign assets.

Since rates of return differ across regions in the short to medium run, it is necessary to know the gross foreign asset position in order to determine income flows from foreign ownership and therefore how regional wealth is affected by a given model simulation. One natural way to pin down a region's gross foreign asset position would be to adopt a portfolio approach, based on a balancing of risks and returns associated with domestic and foreign assets. However in this model, agents are not risk averse and there is no endogenous mechanism for generating risk. Therefore, we are forced to turn to an atheoretic rule. This rule takes into account a set of restrictions. First, *WQHFIRM*(*r*), *WQHTRUST*(*r*) and *WQTFIRM*(*r*) should be positive.[12] Second, equations (15) and (16) should hold. Third, the three variables should satisfy the empirical regularity first documented by Feldstein and Horioka (1980), namely that regions tend to specialize their portfolios strongly in their own domestic assets.

The determinants of international portfolio diversification have attracted considerable attention in the literature (see Lewis (1999) for literature review). Most studies find that international diversification is much lower than the predicted by portfolio allocation models. This is termed the "home bias effect". Kraay *et al*. (2000) demonstrated that, under reasonable assumptions, the probability that international crises occurs twice a century is enough to generate a set of country portfolios that are roughly consistent with the data – i.e. a home-bias in investments. If regions specialize their portfolios strongly in domestic assets in the initial data base, we would like to preserve this relationship over the course of a simulation. In GDyn this is achieved with entropy theory.

[12] The restriction that three variables *WQHFIRM*(*r*), *WQHTRUST*(*r*) and *WQTFIRM*(*r*) are positive is imposed in the model. However, as we will see below in the case of Belgium-Luxemburg, there are real world situations when negative values for *WQHFIRM*(*r*) are possible.

Cross-entropy minimization gives us a way of dividing a strictly positive total into strictly positive components subject to various constraints, while staying as close as possible to the initial shares. Specifically, this method guarantees that: 1) while regional households' equity is changing over time, the split between equity in local firms and equity in foreign firms stays as close as possible to the split in the initial data base; 2) while firms' capital in a region is changing over time, the split between capital belonging to foreigners and capital belonging to local households stays as close as possible to the split in the initial data base. The cross-entropy minimization is summarized by the following equation:

$$(RIGWQH(r) + RIGWQ\_F(r))*wqhf(r) = RIGWQH(r)*wqht(r) + RIGWQ\_F(r)*wqtf(r) \tag{17}$$

where *wqhf*(*r*) is the percentage change in equity held by the regional household in domestic firms (*WQHFIRM*(*r*)), *wqht*(*r*) is the percentage change in equity held by the regional household in the global trust (*WQHTRUST*(*r*)) , and *wqtf*(*r*) is percentage change in equity held by foreigners in a region (*WQTFIRM*(*r*)). *RIGWQH*(*r*) and *RIGWQ_F*(*r*) are rigidity parameters. The *relative* magnitude of the rigidity parameters is important: if *RIGWQH*(*r*) is assigned a high value, and *RIGWQ_F*(*r*) a low value, then from equation (17) $wqhf(r) \approx wqht(r)$. That is, the allocation of household wealth is nearly fixed, and most of the adjustment is put on shares in local capital. The opposite happens if *RIGWQH*(*r*) is assigned a low value, and *RIGWQ_F*(*r*) a high value. Setting *RIGWQH*(*r*) and *RIGWQ_F*(*r*) equal assumes equal adjustment in household wealth shares and regional firms' capital shares.

Indirectly, these parameters determine the allocation of regional savings between foreign and local assets and the split of new investment in a region between domestic and foreign investments. Note that:

$$SAVE(r) = VQHFIRM(r) + VQHTRUST(r) \tag{18}$$

Savings in a region $SAVE(r)$ are distributed between investments into domestic firms $VQHFIRM(r)$ and foreign firms $VQHTRUST(r)$. Similarly,

$$NETINV(r) = VQHFIRM(r) + VQTFIRM(r) \tag{19}$$

represents investment in a region. This may be derived from either the regional household ($VQHFIRM(r)$) or from foreigners ($VQTFIRM(r)$). It can be shown that the change in equity held by regional households in domestic firms ($WQHFIRM(r)*wqhf(r)/100$) is determined by the percent change in the price of old equity $pcgds(r)$ and new investment by regional households in domestic firms[13]:

$$WQHFIRM(r)*wqhf(r)/100 = WQHFIRM(r)*pcgds(r)/100 + VQHFIRM(r) \tag{20}$$

Similarly,

$$WQHTRUST(r)*wqht(r)/100 = WQHTRUST(r)*pqtrust/100 + VQHTRUST(r) \tag{21}$$

Equation (21) states that change in equity held by the regional household in the global trust is determined by change in price of old equity in the trust $pqtrust(r)$ and new investment by the regional household in the global trust $VQHTRUST(r)$. Finally,

$$WQTFIRM(r)*wqtf(r)/100 = WQTFIRM(r)*pcgds(r)/100 + VQTFIRM(r) \tag{22}$$

[13] Note, equations 20-22 and the investment variables are not in the GDyn model code explicitly. They are introduced here to show the effect of the rigidity parameters on the investments and savings allocation. Also, these equations are not technically correct because they should carry time variable.

Equation (22) says that the change in equity held by the global trust in a region is determined by the change in price of old equity *pcgds*(*r*) and new investment in a region *VQTFIRM*(*r*). Let us assume that the effect of a change in price of capital goods is small. Then, if *RIGWQH*(*r*) is assigned a high value, and *RIGWQ_F*(*r*) a low value, the split of regional savings between investing locally and investing abroad will be nearly constant and will fluctuate in the neighborhood of the split of regional household wealth *WQHHLD*(*r*) between wealth in local assets *WQHFIRM*(*r*) and wealth in assets abroad *WQHTRUST*(*r*) in the initial data base, and most of the adjustment will be forced onto the composition of capital and composition of investment in a region, that is on *VQTFIRM*(*r*) and *VQHFIRM*(*r*).

The following hypothetical example, based on a 3x3 aggregation of the GTAP 5.4 Data Base, illustrates the importance of the relative magnitude of the rigidity parameters. To perturb the model, it is assumed that there is an economy wide 5% productivity shock per year to the European economy (EUN) for the first 5 years of the 30 year simulation. Two simulations are compared: 1) rigidity parameters are equal; 2) rigidity parameter *RIGWQH*(*r*), determining the composition of local wealth and distribution of savings, is set 10 times larger than *RIGWQ_F*(*r*).

Figures 7a and 7b show that levels of investment, as well as savings, in a region are equal in both simulations. The positive shock to EUN economy leads to rapid increase in investments in EUN. The difference between the two simulations is how this increase is financed. When EUN wealth and regional savings compositions are more rigid compared to EUN capital composition (*RIGWQH*(*r*)/ *RIGWQ_F*(*r*) = 10), the increase in EUN investment is financed mostly from abroad (figure 7a) and foreigners receive most of the benefits of higher returns in EUN. When *RIGWQH*(*r*)/ *RIGWQ_F*(*r*) = 1, the increase in EUN investment is financed almost equally from domestic and foreign sources. That is, the share of EUN savings invested locally increases after the positive shock to EUN economy and the share of EUN savings invested abroad decreases. In this way the EUN investors participate more fully in the benefits from a positive shock to their domestic economy.

The setting of the rigidity parameters affects the distribution of EUN wealth between local and foreign assets (figures 7c and 7d) and ownership shares of EUN capital in the long run. This means that the long run path of foreign income payments and gross national product (GNP) also depend on the relative magnitude of the rigidity parameters. In short, they are critical to any dynamic general equilibrium analysis with this model.

4.2. Econometric Model and Data

To estimate the relative magnitude of the rigidity parameters, we rearrange equation (17), dividing both sides by the sum $RIGWQH(r) + RIGWQ\_F(r)$, yielding:

$$wqhf(r) = \alpha\, wqht(r) + \beta\, wqtf(r) + e(r) \qquad (23)$$

$$s.t. \ \ \alpha + \beta = 1,$$

where the coefficient $\alpha = RIGWQH(r)/(RIGWQH(r) + RIGWQ\_F(r))$ and $\beta = RIGWQ\_F(r)/(RIGWQH(r) + RIGWQ\_F(r))$. Note that equation (23) does not assert a causal relationship between $wqhf(r)$, $wqht(r)$ and $wqtf(r)$. Rather we are just looking at the relative strength of correlations between the variables. Variables affecting the growth of $WQHFIRM(r)$, and potentially the growth of the two other components $WQTFIRM(r)$ and $WQHTRUST(r)$ are not in the model. If so, it should not be surprising if the explanatory power of the model (23) is low.

To estimate equation (23) national wealth measures are required. Fortunately, such wealth measures were previously constructed, and analysis based on these measures yields meaningful results. Kraay *et al*. (2000) constructed country wealth measures to examine how countries hold their financial wealth. Using the same dataset, Kraay and Ventura (2000) studied current account responsiveness to changes in the terms of trade, transfers from abroad and fluctuations in production. Calderon *et al*. (2003) also used a similar dataset to explore the roles of risk and returns in the evolution of net foreign asset positions of industrial and developing countries. Calderon *et al*. (2003) found that for upper and middle income countries and countries with moderate capital account restrictions, there is a long-run relationship between net foreign assets (relative to country wealth) and the relative measure of returns on domestic investment, the relative measure of investment risk and the ratio of foreign to domestic wealth. In GDyn, net foreign assets are defined as country wealth minus country assets, *WQHHLD*(*r*) –*WQ_FIRM*(*r*). In principal, observations in Calderon *et al*. (2003) could be used to build a new module that would replace the atheoretic entropy method. However, to adopt this theoretical approach, we would need to not only remove the entropy module, but also change the simple expectations mechanism presented in Chapter 2, which would lead to a totally new and much larger model. Therefore, we opt to retain the current specification and use this data set to estimate the key rigidity parameters.

Returning to the wealth measures and the econometric model (23), three growth rates are needed: growth of *WQHFIRM*(*r*), *WQHTRUST*(*r*) and *WQTFIRM*(*r*). We use the country portfolio database constructed by Kraay *et al*. (2000). The database covers 68 countries, listed in Table 3, including all industrial countries and a substantial number of developing countries from 1966 to 1997. The database contains estimates of domestic capital stock, domestic equity owned by foreign residents, foreign equity owned by domestic residents, loans issued by domestic residents and owned by foreign residents, and loans issued by foreign residents and owned by domestic residents. Gross assets abroad *WQHTRUST*(*r*) is foreign equity owned by domestic residents plus loans issued by foreign residents and owned by domestic residents. Gross foreign liabilities *WQTFIRM*(*r*) is domestic capital owned by foreigners and loans issued by domestic residents and owned by foreign residents. *WQHFIRM*(*r*) is simply the difference between domestic capital and gross foreign assets *WQTFIRM*(*r*). For an overview of the data sources, methodology and assumptions used to construct the database, we refer the reader to Kraay *et al*. (2000). The sources used to construct the Kraay *et al*. (2000) database are relatively standard: Penn World Tables for initial stocks of domestic capital, International Monetary Fund's (IMF) Balance of Payments Statistical Yearbook and other sources for direct and portfolio equity stocks and flows and debt stocks and flows, the World Bank's Global Development Finance for debt stocks and flows for developing countries.

While discussion in Kraay *et al*. (2000) is concentrated on how financial wealth of the country is distributed across holdings of domestic capital and various foreign assets, we are interested in the relative rigidity of the allocation of domestic wealth and composition of capital. Figures 8 and 9 show the distribution of gross foreign assets as a share of wealth and gross foreign liabilities as share of capital respectively, pooling the available 1717 observations with non-missing values for all countries and years. Gross foreign assets positions are small: for 75 percent of the observations gross foreign assets as share of wealth are less than 14 percent. Gross foreign liabilities as a share of capital are some what larger but for 75 percent of the sample still represent less than 25 percent of capital. On both graphs, observations with values greater than 1 represent Belgium-

Luxemburg. Toward the end of the sample period, Belgium-Luxemburg keeps most of its wealth abroad, and at the same time borrows more than the size of its capital stock, which results in the observed gross foreign assets and liabilities shares greater than 1. Table 4 shows variation of gross foreign assets and liabilities across regions and over time.

Claims on foreign assets represent only 4.3 percent of the wealth in developing countries, while foreign claims on domestic assets consist of 11 percent of domestic capital. For industrial economies, claims on foreign assets and claims of foreigners on domestic assets are balanced and represent 14.8 percent of wealth and 14.9 percent of capital, respectively. For industrial countries, the shares of gross foreign assets and gross foreign liabilities in wealth are increasing over time, indicating increasing integration of capital markets. On the other hand, the data for developing countries show no strong pattern.

It is interesting to note that gross foreign assets and liabilities consist primarily of loans rather than equity (Kraay *et al*., 2000). However gross foreign assets and liabilities composition is of less interest for our discussion, since in the GDyn there is only one class of financial assets – equity. This is driven by the consideration that the role of financial assets in the GDyn model is to support international capital mobility rather than to represent the financial sector per se. Driven by this consideration, the data on gross foreign assets and liabilities, consisting of both equity and loans, are chosen for the analysis.

4.3. Empirical Results

We start our analysis by analyzing the relationship between growth rates *wqhf*(*r*), *wqht*(*r*) and *wqtf* (*r*). Figures 10a - 10c show correlations between these variables in high income, middle income and lower income countries. Countries on the horizontal axis are ordered by average per capita income over the sample period.[14] Figure 10a shows that for the majority of industrial countries correlations between growth in gross foreign assets (*wqht*(*r*)) and growth in gross foreign liabilities (*wqtf*(*r*)) are much stronger than correlations between *wqhf*(*r*) and *wqht*(*r*), or between *wqhf*(*r*) and *wqtf*(*r*). This suggests a high degree of integration in the global economy. The story for developing countries presented on Figures 10b and 10c is very different from the one for industrial economies. Overall, correlations are smaller, and the correlations between growth rates of gross foreign assets and liabilities (*wqht*(*r*) with *wqtf*(*r*)) are much smaller than correlations between composites of capital (*wqhf*(*r*) with *wqtf*(*r*)) and wealth (*wqhf*(*r*) with *wqht*(*r*)) compared to Figure 10a. What makes the pattern for developing countries so different? There are two possible explanations. First, the developing countries are less integrated in the global economy. Comparison of Figures 10b and 10c reveals that as we move across the per capita income spectrum (the countries are ordered by average over 1966-1997 period per capita income from India (IND) on Figure 10b to Trinidad and Tobago (TTO) on Figure 10c), correlations for developing countries become more and more like ones of industrial countries. As developing countries become richer, the correlations between growth rates of external positions become higher suggesting a higher degree of integration in the global economy. Our second explanation is based on the nature of the data. The data for developing countries is much more sparse and incomplete, and a set of

[14] Nine countries with less than 14 observations are omitted from the analysis here and in econometric analysis below. These countries are Bangladesh (BGD), Switzerland (CHE), Chile (CHL), Cameroon (CMR), Congo (COG), Egypt (EGY), Saudi Arabia (SAU) and Senegal (SEN).

assumptions is used to construct the database (see Kraay *et al*. (2000)). These factors could also contribute to the differences that we see on Figure 10a and Figures 10b and 10c.

The globalization effect observed in industrial countries creates a problem for us. Since correlation between the independent variables in econometric model (23) is very strong – Sweden (SWE) is an extreme case - there is a multicollinearity problem and we cannot distinguish the estimated coefficients from zero in the model (23). The integration into the world economy masks the relationship between growth in composites of wealth and capital. To overcome the multicollinearity problem, we rewrite the restriction as $\beta = 1 - \alpha$, substitute the restriction into the model (23) and rearrange the equation:

$$wqhf(r) - wqht(r) = \beta\,(wqtf(r) - wqht(r)) + e(r) \tag{24}$$

Equation (24) allows comparison of the rigidity of allocation of wealth and composition of capital even in the case of industrial countries where correlations between $wqht(r)$ and $wqtf(r)$ are strong.

The ordinary least squares (OLS) method, the standard linear regression procedure, assumes that errors are uncorrelated and the variance of error terms is homoscedastic. When data are time series, as in equation (24), these assumptions could be violated and need to be tested before applying OLS. If regression disturbances follow autoregressive scheme or their variance is not constant through time, the least squares estimator's variances are biased and could not be use for testing hypothesis. We use Durbin-Watson test for first order autocorrelation. To see whether variance is non constant through time, we test for the presence of autoregressive conditional heteroskedasticity (ARCH) process developed by Engel (1982).[15] ARCH models recognize successive periods of relative volatility and stability, and treat heteroskedasticity as a variance to be modeled. Note that here we are not interested in the variance itself, rather we want to correct the standard errors to be able to accurately test a statistical hypothesis.

We found the presence of first order autocorrelation in all industrial countries and some developing countries.[16] The null hypothesis of constant variance is not rejected for all countries, except the United Kingdom, Israel, Ireland and Greece. In the United Kingdom and Ireland, the test result is driven by a large squared error in 1997. In 1997, the proportionate change in equity held by the regional household in domestic firms *wqhf* is abnormally large by absolute magnitude and negative, and is driven by the shift in composition of wealth toward assets abroad in both countries. Dropping 1997 from the estimation results in homoskedastic variance. In the cases of Greece and Ireland, it seems that test for non-constant variance picks autoregressive error process, since after the correction for first order autocorrelation the hypothesis of homoskedasticity cannot be rejected. While in the case of the United Kingdom and Israel, heteroskedasticity persists after correction for first order autocorrelation. For these four countries ARCH (1) model was estimated (Engle, 1982).[17] The results of this estimation for coefficient β in equation (24) are very similar to results obtained from estimation with a simple correction for first order autocorrelation in terms of magnitude of obtained estimates of β and identical in terms of test β=1 outcomes. Since results of the more complex ARCH are similar to

[15] The standard test for ARCH of order q process is used, where the OLS squared residuals in model (3.10) are regressed on a constant and q lags. Then, we compare the $N*R^2$ value (where N is sample size and R^2 is R-square measure of fit) with a χ^2 distribution with q degrees of freedom (see Shazam user's reference manual, for example).

[16] First order autocorrelation was found in all industrial countries, with the exception of Belgium-Luxemburg where we did not test for autocorrelation because of a break in the time series data.

[17] Higher order ARCH coefficients in the variance equation are not significant.

results of the simpler method, for Israel we report results based on OLS (where no autocorrelation is found), and for the other three countries based on maximum likelihood estimation method which allows correction for first order autocorrelation.

Estimation results for equation (24) are presented in Table 5. The estimates of coefficient β in equation (24) and its significance level are reported in column 2. Where necessary, we correct for first order autocorrelation.[18] The associated autocorrelation coefficient and its significance level are shown in column 3. The Durbin-Watson Statistic calculated after the correction for first order autocorrelation and model fit are shown in columns 4 and 5, respectively. In column 6 we report results from testing the hypothesis that coefficient β is equal to one. This would be the case if the composition of capital is rigid and allocation of wealth is flexible. If coefficient β is not different from zero, we also test if $\alpha = 1 - \beta$ is not different from 1 to see if allocation of wealth is rigid, given that composition of capital is flexible.

Based on the results reported in Table 5, countries can be grouped into four categories. The first group of countries is characterized by the rigid composition of capital and flexible allocation of wealth. This group includes most of the developing countries in our sample, except for Singapore (SGP), and 13 of 20 industrial countries.[19] For these countries, coefficient β is highly significant and in most cases is not statistically different from 1, meaning that $\alpha = 1 - \beta$ is zero and the allocation of wealth is very flexible. The second group consists of countries where coefficient β is small in absolute

[18]If regression disturbances follow an autoregressive scheme, the least squares estimator of the regression coefficients is not asymptotically efficient, and estimator's variances are biased and cannot be use for testing hypothesis. In these cases we introduce an autocorrelation coefficient into the model and estimate it together with coefficient β using full unconditional maximum likelihood estimation method.
[19] Though Singapore is highly industrialized country with high per capita income, we include this country in East Asia and the Pacific group simply because it was included in this group in the Kraay et al. (2000) data base.

magnitude and statistically is not different from zero, while $\alpha = 1 - \beta$ is not different from one. These are industrial countries and include: Germany (DEU), United Kingdom (GBR), Japan (JPN), Sweden (SWE), United States (USA) and Singapore (SGP). In these economies the composition of wealth is rigid and the composition of capital is flexible. The third group is represented by countries wherein both compositions are rigid. Here, the coefficients β and α are both significant and less than one. Depending on their relative magnitude, one composition is more rigid than another. This group consists of one industrial country (Norway (NOR)) and some of the developing countries: Bolivia (BOL), Ecuador (ECU), Malaysia (MYS), Thailand (THA), Jordan (JOR), Morocco (MAR), Sri Lanka (LKA) and Mauritius (MUS). Finally, the fourth group consists of Austria (AUS) and France (FRA). In these cases, the coefficient β is not different from zero, but at the same time it is not different from one. Similarly, $\alpha = 1 - \beta$ is neither different from one nor from zero. We interpret this as representing the case where both the capital and wealth compositions are equally flexible, or equally rigid.

Having the question what are the relative rigidities of composition of capital and allocation of wealth in the countries present in Kraay *et al*. (2000) database answered, the issue of how to generalize results for all other countries needs to be addressed. To answer this question we create a balanced panel that covers 1975 – 1994 period (20 years) and includes 40 countries. Comparing number of countries by region analyzed in Table 5, these 40 countries represent 17 of 20 industrial countries (INDC), 11 of 16 Latin American countries (LAC), 5 of 7 East Asia and the Pacific countries (EAP), 3 of 9 Middle East and North Africa countries (MENA), 2 of 3 South Asia countries (SA) and 2 of 3 countries in Sub-Saharan Africa (SSA) region. Thus, all regions of Kraay *et al.* (2000) database are represented relatively well in the panel, except MENA. To see whether the shorter time period covered in this panel, as compared to the longer periods covered in the separate country regressions in Table 5, could potentially influence the result of the panel estimation, we repeated Table 5 estimation for each country for 1975 – 1994. We found that estimates of β and results of the tests $\beta = 1$ are very robust with respect to choice of time interval.

In estimating econometric equation (24) we use a pooling technique similar to one described in Kmenta (1986). Specifically, we assume that the model is a cross-sectionally heteroskedastic and timewise autoregressive. Since the model (24) is likely to suffer from omitted variables problem – variables that influence all cross-sectional units – we also assume that error terms are cross-sectionally correlated. However, the estimation of model (24) under these three assumptions about error terms appears to be problematic. The problem is that for this particular data set, where the number of cross-sectional units is twice larger than the number of time periods, the variance-covariance matrix is close to singular and cannot be inverted. There are two possible approaches to overcome the problem. The first approach is to estimate model (24) under the three assumptions, but with smaller number of cross-sectional units, that is using subsets of 40 countries. The second approach is to drop the assumption of cross-sectional dependence. As we will see, the results are consistent across these two approaches and also with the results reported in Table 5.

The estimation results of equation (24) as cross-sectionally correlated and time-wise autoregressive model for each of the six geographic regions are presented in the first part of Table 6. For the group of industrial countries (INDC), the estimated coefficient β is 0.984, which is close to 1, but different from 1 statistically. From regression results for each INDC country reported in Table 5, we see that the estimated β varies from country to country and for 8 of 20 of countries is different from 1. Thus, the result obtained using the pooling technique is consistent with the results based on separate regression for each of INDC countries and suggests that in INDC composition of capital is much more rigid than the allocation of wealth. For the Latin America region, the estimated β is 0.884 and the hypothesis $\beta = 1$ is strongly rejected. The latter is somewhat surprising since in separate regression model for each country (Table 5) the hypothesis $\beta = 1$ cannot be rejected for the majority of Latin America countries. However, both pooled and individual country models support the hypothesis that for LAC region the composition of capital is more rigid than the allocation of wealth. In MENA, where pooled data include only Israel (ISR), Tunisia (TUN) and Turkey (TUR), estimated β is 0.772 and statistically different from 1. Again, this is somewhat surprising given that in separate regressions for these three countries (Table 5); where β is statistically different from 1 only in Turkey (TUR). But, the results based on pooling technique do not alter the conclusion achieved with country by country regressions, that the composition of capital is more rigid than the composition of wealth in the MENA region. In support of these, we test and reject the hypothesis that $\beta = 0.5$, which is the test for equal rigidity of the two compositions.

In East Asia and the Pacific (EAP) and South Asia (SA) estimated β is not statistically different from 1, which is consistent with the results reported in Table 5 for countries in these regions. In the Sub-Saharan Africa (SSA), the estimate of β is significantly different from zero but less than 1. To see whether compositions of capital and wealth have similar degrees of rigidity, we test the hypothesis $\beta = 0.5$, and reject it only at the 10% significance level. This suggests that for SSA the rigidities of composition of capital and wealth are very similar. Note, that the results obtained for

MENA, SA and SSA could be generalized to other countries (not included in estimation and/or in the Kraay *et al*. (2000) database) in these regions with caution, because panel data used in estimation for each of these regions is not representative.

Now we estimate the regression model (24) pooling all 40 countries together assuming time-wise autoregression, cross-sectional heteroskedasticity, but cross-sectional independence. First, we restrict the slope coefficients to be the same for all six regions and then allow heterogeneous slopes to test for differences across regions. The results are reported in the second part of Table 6. The results reported in the first and second parts of Table 6 are very similar in terms of the magnitude of the estimated β and the results of the test β=1, except for INDC region. Taking into account cross-sectional correlation among countries in the INDC region appears to be important, particularly when testing whether β is significantly different from 1. When we ignore the omitted variables problem for industrial countries, the estimate of β is not statistically different from 1. Finally, restricting all β to be equal for all countries results in an estimate of β very close to 1, suggesting that the composition of capital is much more rigid than the allocation of wealth for all countries considered.

4.4. Rigidity Parameters

This section summarizes findings about relative rigidity of composition of capital and allocation of wealth in terms of recommendations for the setting of rigidity parameters in GDyn model.

The capital stock of a region consists of two assets: domestic capital owned by domestic residents and gross foreign liabilities. The wealth of a region is also held in a two asset portfolio composed of domestic capital owned by domestic residents and gross foreign assets represented by shares in the global trust. Changes in the compositions of wealth and capital over time are determined by investors' decisions on how much of their savings should be invested domestically, and how much should be sent abroad. In the real world, when forming their portfolios, investors take into account not only relative returns to capital, but also risk. In GDyn, investors will reallocate capital from regions with lower rates of return to regions with higher rates of return; however, the model does not account for the risk-related portion of this investment decision. Therefore, to determine the composition of capital and allocation of wealth, we adopt the atheoretic rule (17). Indirectly, this rule determines the allocation of regional savings between foreign and local assets and the split of new investment in a region between domestic and foreign investments. The relative magnitude of the rigidity parameters in (17) determines the relative rigidity of the composition of wealth and capital.

The rigidity parameters are weights in a weighted sum of two cross-entropies – one associated with local capital ownership shares and another with wealth allocation shares. This weighted sum is minimized to keep the composition of capital and the allocation of wealth as close as possible to the split in the initial data base. Only nonnegative values of the rigidity parameters are consistent with cross-entropy minimization and only one of the rigidity parameters can be zero, not both.[20] Although one of the rigidity parameters can be set to be zero in the model, such a parameterization makes the model more fragile. If, for example, *RIGWQH*(*r*) is set to zero, and there is a high investment in a region, the local household may be required to invest more than one hundred per cent of its savings in local firms. In this sense, a zero value is not desirable.

[20] Setting both parameters to zero will eliminate relationship (17) from the model.

Using the data on composition of wealth and capital stocks for 68 developing and industrial countries (Kraay *et al*., 2000), we investigated the relative rigidity of the composition of capital and wealth. Our findings are summarized in Table 7 in terms of recommendations for the setting the rigidity parameters in GDyn. When setting the parameters, we take into account restrictions on the parameter space as it is discussed above.

For the majority of countries, including all developing countries except Singapore (SGP) and 13 industrial countries, the composition of capital is much more rigid than the allocation of wealth. The coefficient $\beta = RIGWQ\_F(r)/(RIGWQH(r) + RIGWQ\_F(r))$ is not different from one, and coefficient $\alpha = RIGWQH(r)/(RIGWQH(r) + RIGWQ\_F(r))$ is not different from zero. For these countries we could reasonably set *RIGWQH*(*r*) equal to zero and *RIGWQ_F*(*r*) set equal to one. However, because $RIGWQH(r) = 0$ makes the model rather fragile, we advise setting *RIGWQH*(*r*) to a small positive number, for example 0.01. In many cases, the estimated β is greater than 1 which suggests that $\alpha = 1 - \beta$ is negative. It is not a problem when β is not significantly different from 1 and the coefficient α is negative, but not different from zero. However, cases such as Australia (AUS) and the Netherlands (NLD) are problematic because β is significantly greater than one (see columns 2 and 3 in Table 7), and the coefficient α is significant and negative which leads to a negative *RIGWQH*(*r*). Since negative rigidity parameters are not allowed in the model, *RIGWQH*(*r*) is set to 0.01 and *RIGWQ_F*(*r*) to 1 for Australia (AUS) and Netherlands (NLD).

In the second group of countries the composition of wealth is much more rigid than the composition of capital. In the case of Germany (DEU), United Kingdom (GBR), Japan (JPN), Sweden (SWE), United States (USA) and Singapore (SGP), β is not different from zero and α is not different from one. For these countries we set *RIGWQH*(*r*) to one and *RIGWQ_F*(*r*) to 0.01. In the third group, consisting of Bolivia (BOL), Ecuador (ECU), Malaysia (MYS), Thailand (THA), Jordan (JOR), Morocco (MAR), Sri Lanka (LKA), Mauritius (MUS) and Norway (NOR), both compositions are rigid. For these countries we tested if $\alpha=\beta=0.5$, and for all nine countries except for Bolivia (BOL) and Ecuador (ECU) where β is close to one, we could not reject the hypothesis that both, capital and wealth, have a very similar degree of rigidity. For these countries, we set *RIGWQ_F*(*r*) = *RIGWQH*(*r*) = 1. In Bolivia and Ecuador, the composition of capital is slightly more rigid than the composition of wealth. For these countries *RIGWQ_F*(*r*) is set to 1 and *RIGWQH*(*r*) is calculated as $(1-\beta)/\beta$. Finally, in Austria (AUT) and France (FRA) both splits are very flexible. Since we cannot set rigidity parameters to zero in the model, we make them equal, in this case setting them both to 1.

Using the regression results reported in Table 6, we set rigidity parameters for countries that are not part of the Kraay *et al*. (2000) database. From the very last row in Table 6, we conclude that in the "average" country the composition of capital is much more rigid than the allocation of wealth. However, β is significantly less than 1. The parameter *RIGWQ_F*(*r*) is set to 1 and *RIGWQH*(*r*) = $(1-\beta)/\beta = 0.06$. Regional βs reported in Table 6 may also be used. For industrial countries (INDC), Latin America countries (LAC) and East Asia and the Pacific (EAP), *RIGWQ_F*(*r*) is set to 1, and *RIGWQH*(*r*) is calculated as *RIGWQH*(*r*) = $(1-\beta)/\beta$, where βs are estimates reported in the first part of Table 6. This calculation results in *RIGWQH*(*r*)= 0.05 for INDC, *RIGWQH*(*r*)= 0.13 in LAC. *RIGWQH*(*r*)= 0.01 in EAP. For country in Middle East and North Africa (MENA), South Asia (SA) or Sub-Saharan Africa (SSA) region, the “average” country setting of the rigidity parameters – *RIGWQ_F*(*r*) = 1 and *RIGWQH*(*r*)= 0.06 – is more desirable since results for these three regions in Table 6 are based on only 2 or 3 countries. Since in the majority of countries considered the composition of capital is much more rigid than allocation of wealth, for post-aggregation regions *RIGWQ_F*(*r*) can be set to 1 and *RIGWQH*(*r*) set to 0.06.

While there are differences in the relative rigidities of the composition of capital and allocation of wealth across countries, in the majority of countries the split between capital belonging to foreigners and capital belonging to local households is much more rigid than the split between equity in local firms and equity in foreign firms. The exceptions to this rule are offered by six industrialized countries. This apparent empirical regularity warrants further theoretical and empirical investigation. One possible explanation for this phenomenon may be based on asymmetric information. In the majority of countries domestic investors may have much better information about the investment opportunities in the domestic economy than do foreign investors. When good times come, domestic investors reallocate their portfolio to capture higher returns generated by domestic assets. And they do it faster and with greater ease than foreign investors. Similarly, when returns to domestic capital fall, domestic investors are likely to be the first to reallocate their portfolios toward foreign assets. This asymmetric information would result in the observed flexible allocation of wealth and rigid composition of capital.

4.5. Aggregation Issues

The solution to the aggregation issue of the rigidity parameters is straight forward. Since in the majority of countries the split between capital belonging to foreigners and capital belonging to local households is much more rigid than the split between equity in local firms and equity in foreign firms, for post-aggregation regions *RIGWQ_F*(*r*) =1 and *RIGWQH*(*r*) = 0.06. Region specific parameters reported in Table 7 may also be used for regions or a country in a specific region. If the user would like to use different values of the parameters at the country level reported in Table 5 to determine parameters for a region (i.e. aggregation of countries), an aggregate method is required at the regional level. In our aggregation method we use the wealth of the regional household (coefficient *WQHHLD*(*r*)) to aggregated *RIGWQH*(*r*) and value of the domestic capital stock (coefficient *WQ_FIRM*(*r*)) to weight *RIGWQ_F*(*r*).

5 Summary

This chapter develops econometric underpinnings for the behavioral and entropy parameters in the GDyn model to add realism to the projections with the model. The long-run equilibrium in the model is defined as the convergence of the risk adjusted net rates of return to capital across regions. In this chapter, the rates of return to capital are constructed using gross operating surplus obtained from the SourceOECD database and capital stock documented in Larson *et al*. (2000). These returns are used to test the hypothesis of convergence in rates of return across countries and to measure the degree of international capital mobility. Based on econometric analysis, the null hypothesis of no convergence is rejected. The speed of convergence in net rates of return to capital in 20

OECD countries is 9% per year. Most likely, this speed of convergence would be lower if we included countries outside OECD, and hence a speed of convergence of 9% per year represents the upper bound of the desirable convergence of the net rates of return in the model.

By changing the parameters determining speed of 1) lagged adjustment of the expected rate of return toward actual rate of return and 2) lagged adjustment of the expected rate toward the target rate, the desirable degree of capital mobility can be achieved in the model. However, the same magnitude of the parameters may result in different degrees of capital mobility depending on regional aggregation. Because of this, the lagged adjustment parameters should be calibrated on simulated rates of return for every new regional aggregation. The calibrations of lagged adjustment parameters for 3x3 and 7x7 aggregations of the GTAP Data Base demonstrated that the speed of convergence of 9% can be achieved when the lagged adjustment parameters are set to 0.5 and 0.4, respectively. This may suggest that in scenarios based on more disaggregated GTAP Data Base, the desirable degree of capital mobility in the model can be achieved by setting the lagged adjustment parameters to some lower value.

This chapter also discusses the approach to setting of the elasticity of rate of return with respect to the size of capital stock. The first best solution is to calibrate the elasticity on the post-aggregation data base. The second best is to set it to 1. Setting the elasticity of the rate of return far from its model consistent value may adversely affect convergence properties of the model.

The lagged adjustment mechanisms determine regional investments which include both domestic investment and foreign investment via the global trust. Savings of the regional household, in turn, are spent on investment in the domestic economy and investments in the global trust. Period by period decisions about the investments and savings composition affect the composition of capital and allocation of wealth of a region. In this chapter the parameters determining the relative rigidities of composition of capital and allocation of wealth in the GDyn model are estimated using country portfolios database. While there are differences in the relative rigidities of the composition of capital and allocation of wealth across countries, in the majority of countries the split between capital belonging to foreigners and capital belonging to local households is much more rigid than the split between equity in local firms and equity in foreign firms. The results of the econometric investigation are used to set the rigidity parameters in the model.

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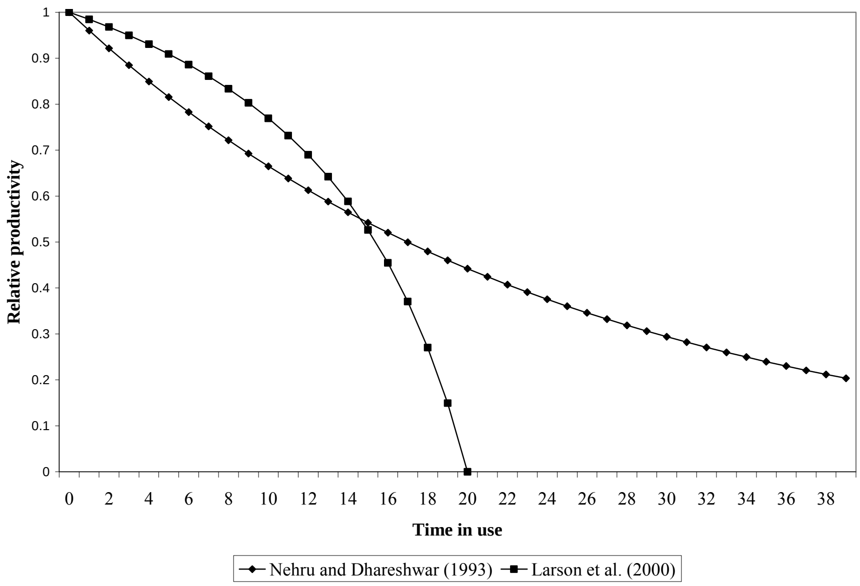
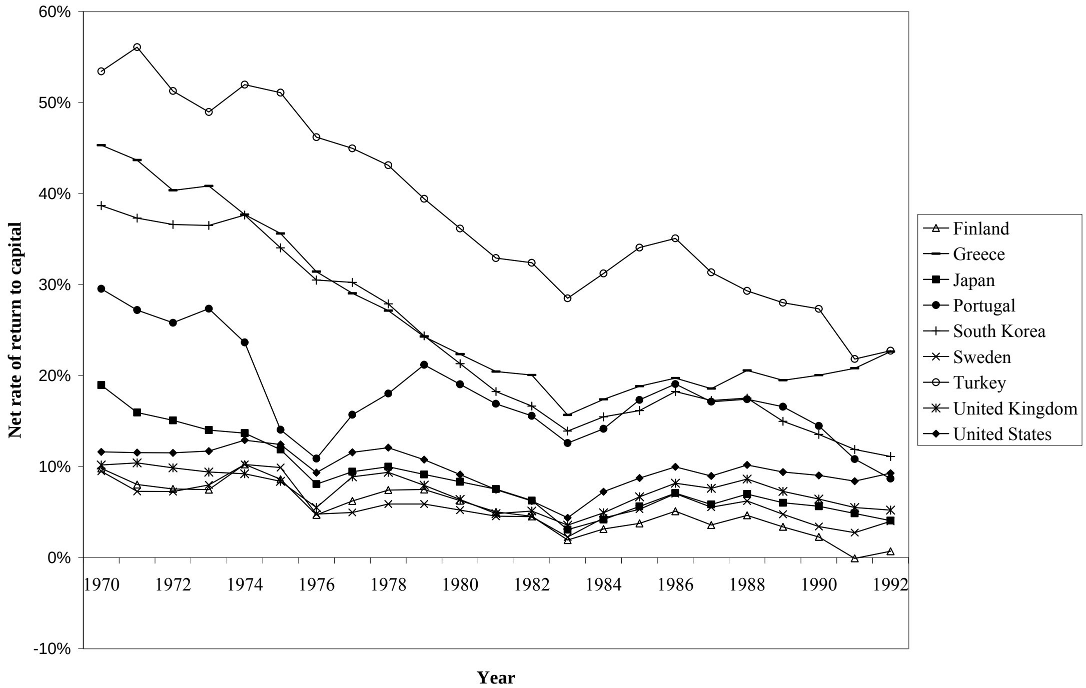
Figure 1 Comparison of the relative productivity paths in Nehru and Dhareshwar (1993) and Larson *et al*. (2000)



Geometric decay path in Nehru and Dhareshwar (1993) is based on 4% decay rate. Larson *et al*. (2000) built the path of productivity of total economy-wide fixed capital assuming 20 years of service life and curvature parameter $\beta = 0.7$. Source: authors' calculations.

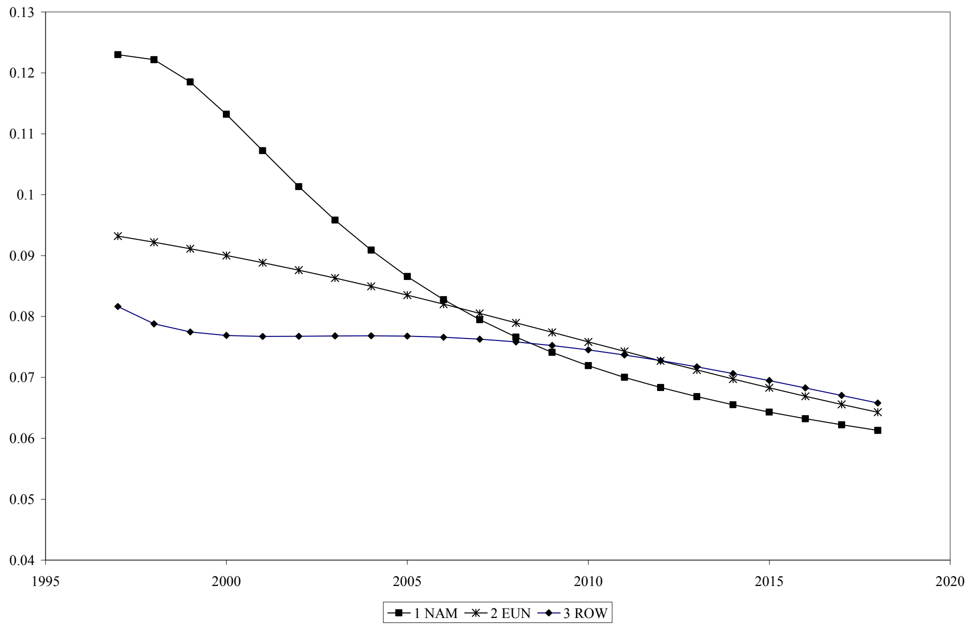
Source: Author's calculation.

Figure 2 Net rates of return of return to capital in OECD countries



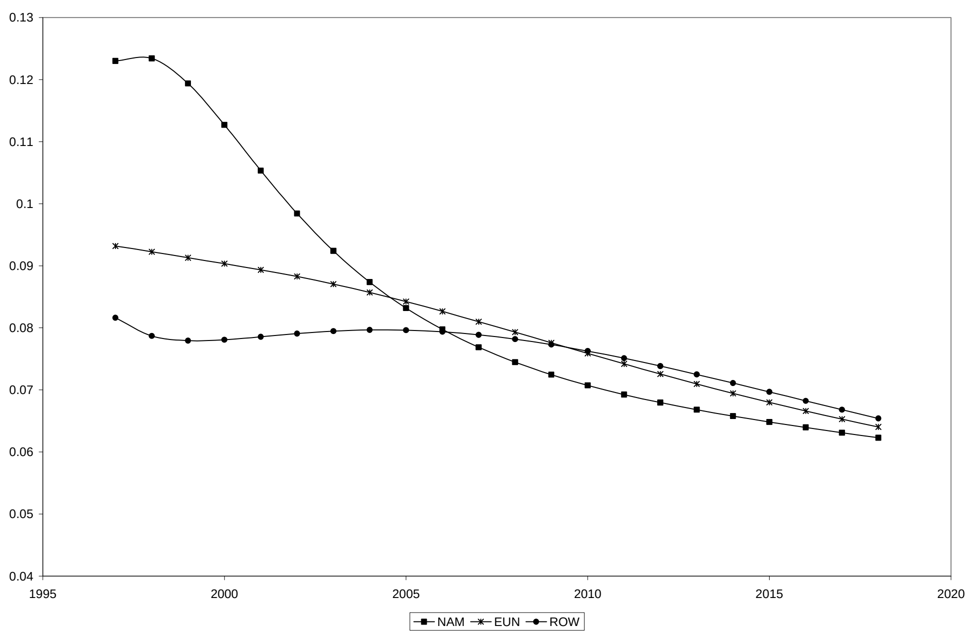
Source: Author’s calculation.

Figure 3 Convergence of net rates of return to capital when *LAMBRORG*=0.4 and *LAMBRORGE*=0.4.



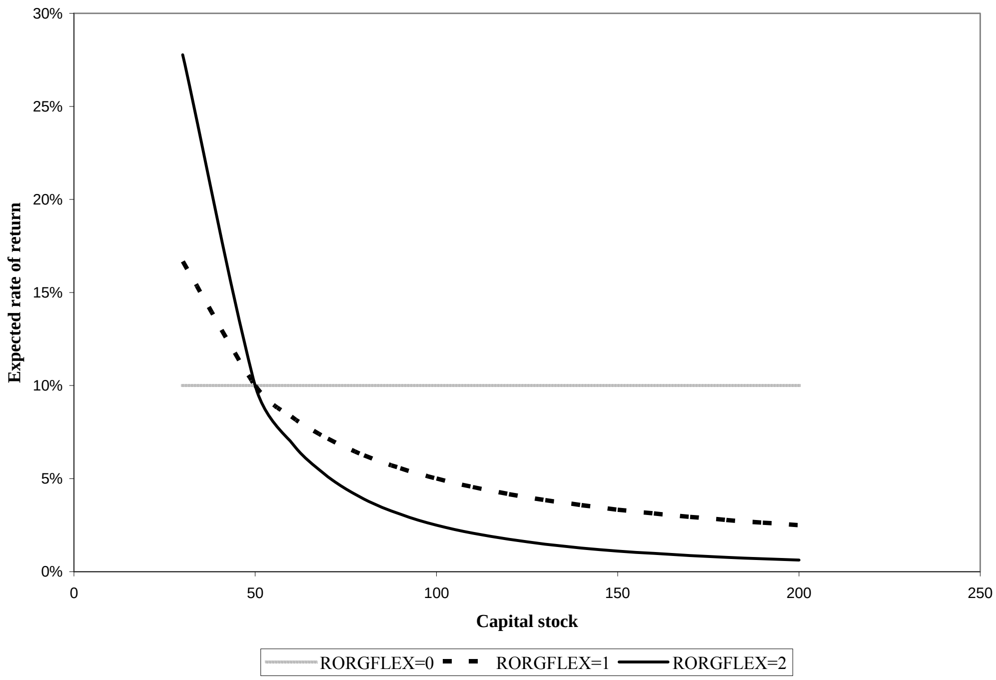
Source: Authors' simulations with GDyn.

Figure 4   Convergence of net rates of return to capital when *LAMBRORG*=0.5 and *LAMBRORGE*=0.5



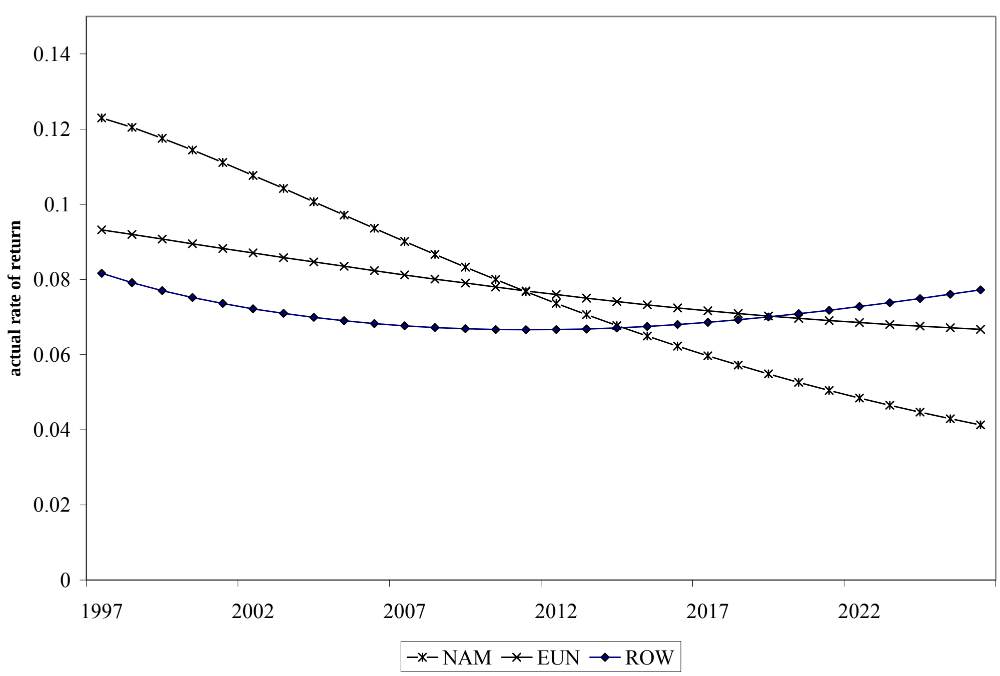
Source: Authors' simulations with GDyn.

Figure 5 The effect of different values of the elasticity of rate of return on the expected rate of return schedule



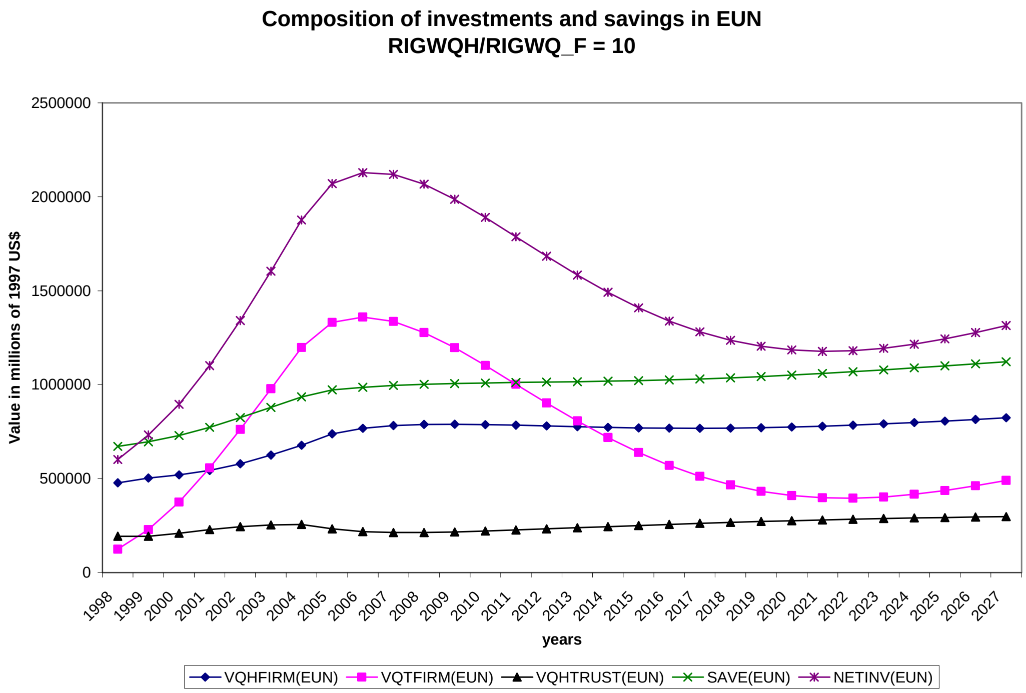
Source: Author's calculation.

Figure 6 Divergence of net rates of return to capital when *RORGFLEX* = 5, five times larger than model consistent value



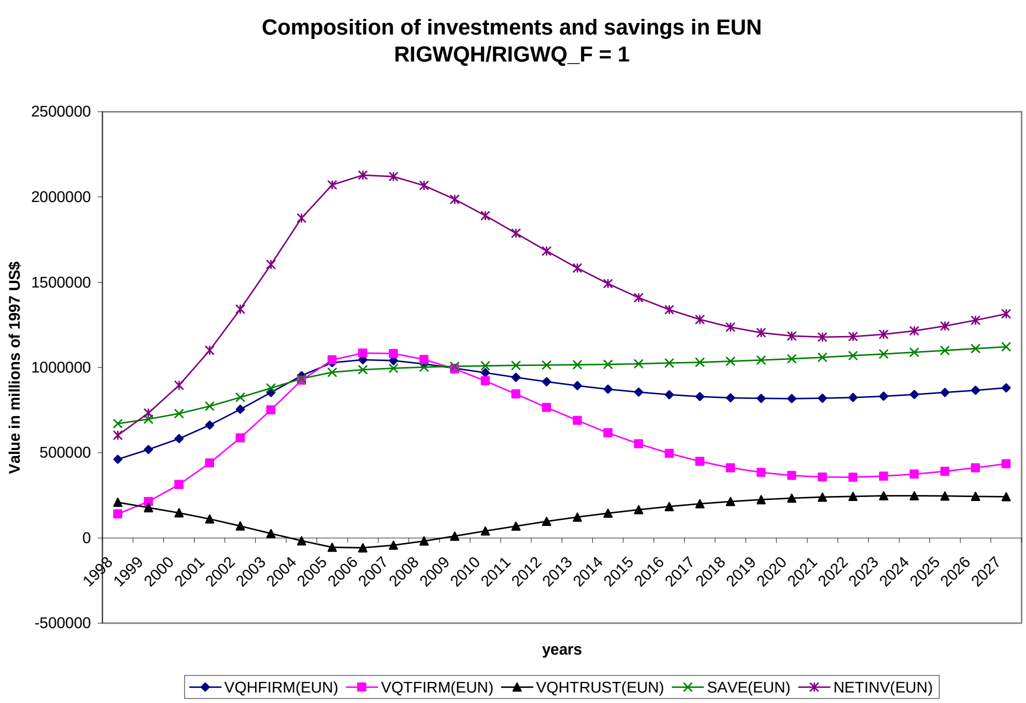
Source: Authors' simulations with GDyn

Figure 7a



Source: Author's simulation with GDyn

Figure 7b



Source: Author's simulation with GDyn

Figure 7c

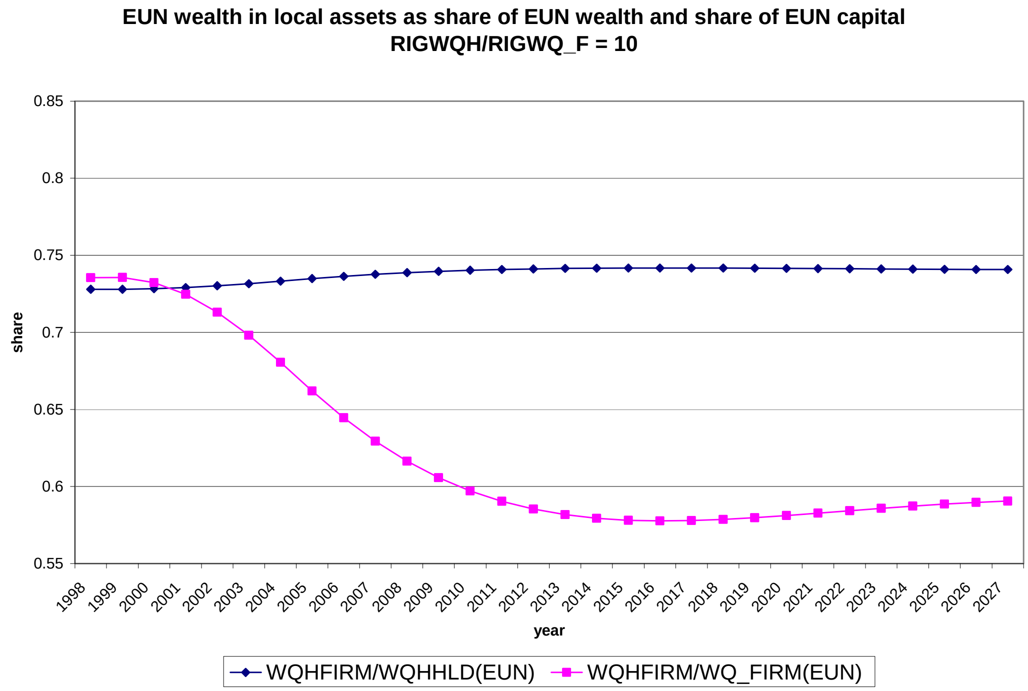


Figure 7d

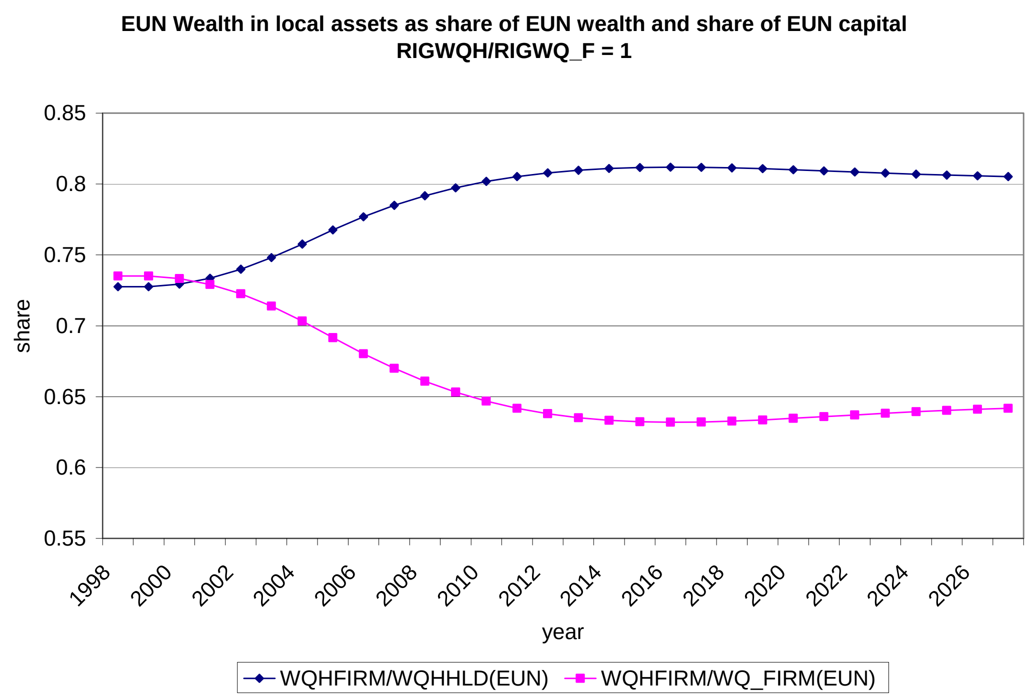


Figure 8 Distribution of gross foreign assets as share of wealth, pooling the available 1717 observations with non-missing values for all countries and years in Kraay *et al*. (2000) database

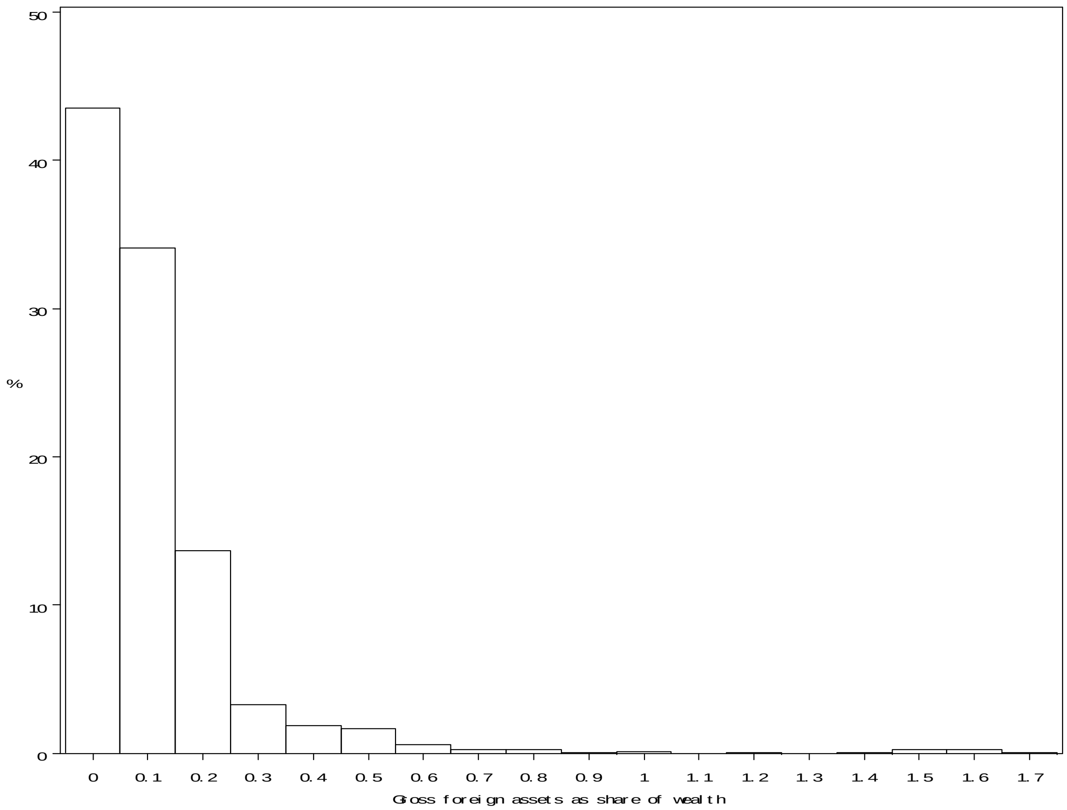


Figure 9 Distribution of gross foreign assets as share of capital, pooling the available 1717 observations with non-missing values for all countries and years in Kraay *et al*. (2000) database

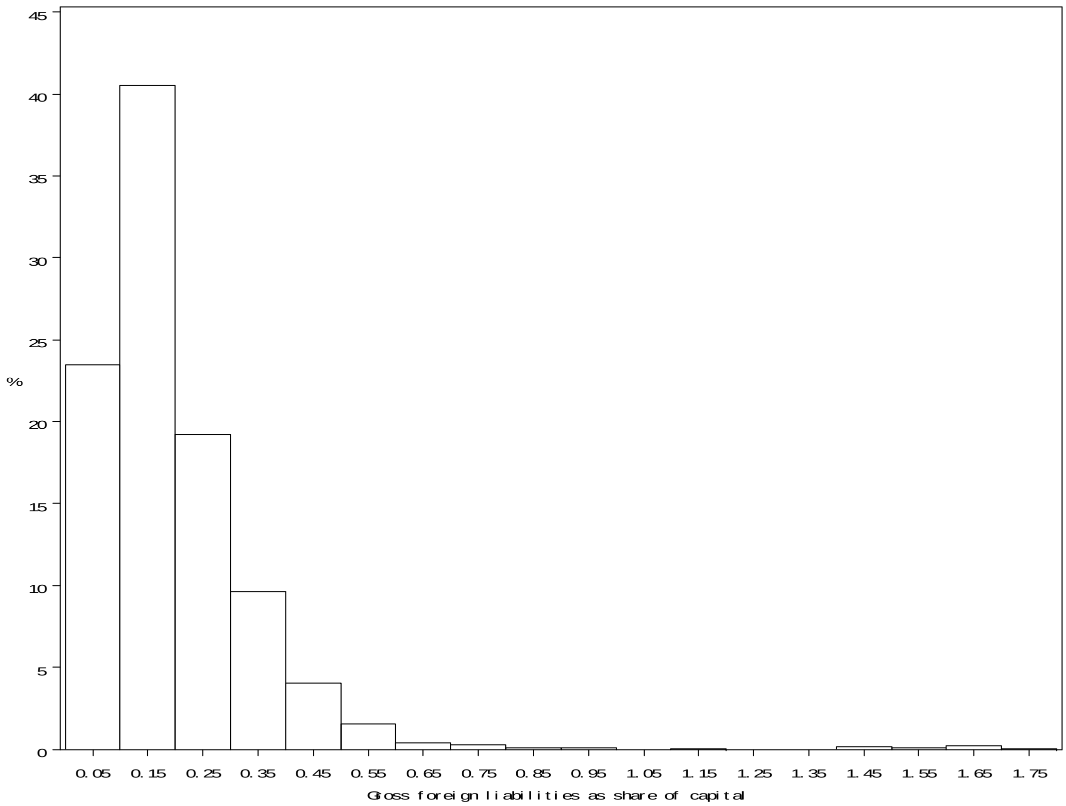


Figure 10a   Correlations between wghf(r), wqht(r) and wqtf(r) for industrial countries

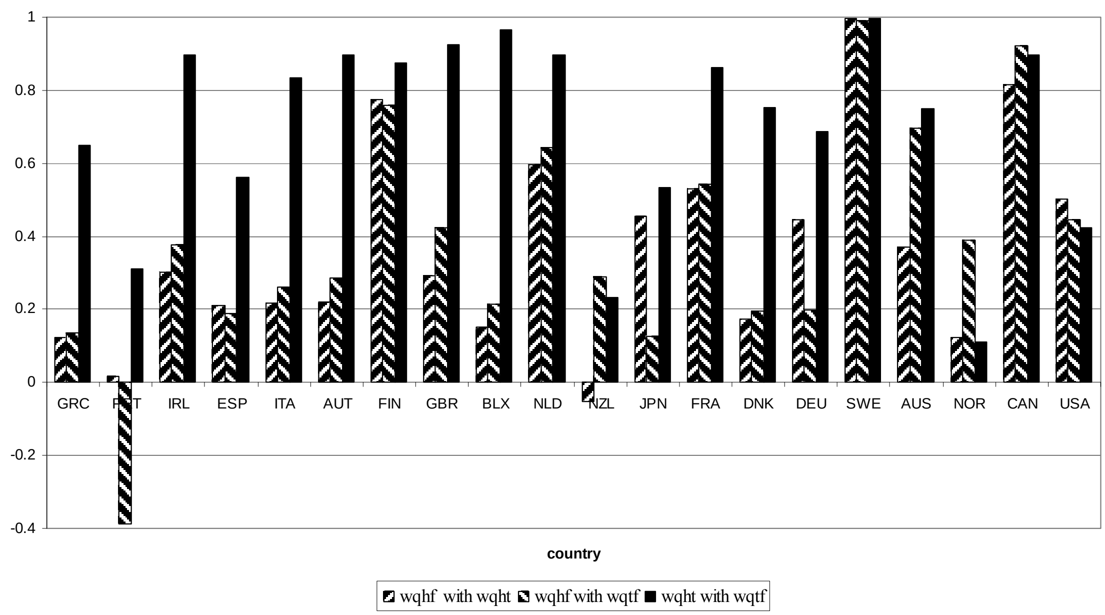


Figure 10b Correlations between wghf(r), wqht(r) and wqtf(r) for low per capita income developing countries

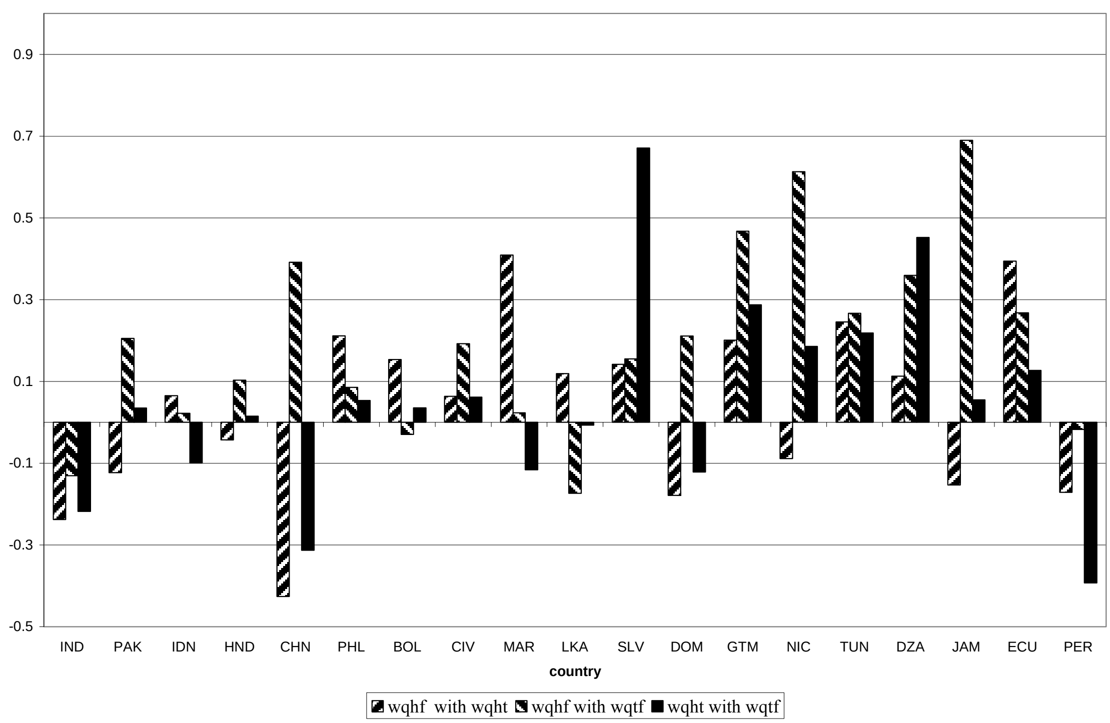


Figure 10c   Correlations between wghf(r), wqht(r) and wqtf(r) for middle per capita income developing countries

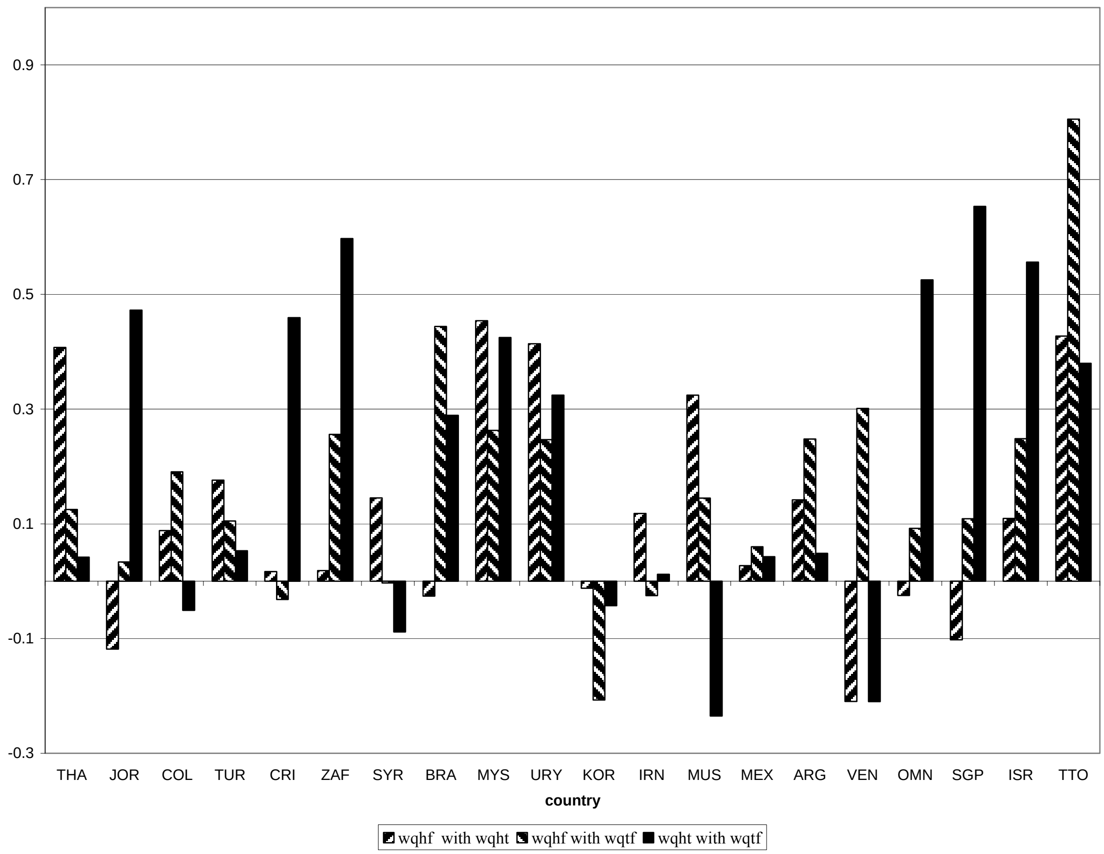


Table 1 Contents of the dynamic parameters file

Coefficient Name	**Dimensions**	**Description**
INC	REG[21]	initial income
LAMBKHAT	REG	coefficient of adjustment in estimated normal growth rate
LAMBRORGE	REG	coefficient of adjustment in expected rate of return
LAMBRORG	REG	coefficient of adjustment in rate of return
RORGFLEX	REG	elasticity of rate of return to capital with respect to capital stock
RIGWQH	REG	rigidity of allocation of wealth by regional household
RIGWQ_F	REG	rigidity of source of funding of enterprises

Table 2 Time series test for convergence of rates of return to capital for 20 OECD countries*

Parameter	Estimate	Std. Error	t - value	Pr > |t|
Australia (mu1)	0.001	0.003	0.320	0.749
Austria (mu2)	-0.002	0.003	-0.880	0.382
Belgium-Luxemburg (mu3)	0.003	0.003	0.920	0.361
Canada (mu4)	0.002	0.003	0.600	0.546
Denmark (mu5)	-0.001	0.003	-0.450	0.651
Finland (mu6)	-0.004	0.003	-1.300	0.195
France (mu7)	-0.001	0.003	-0.240	0.810
Greece (mu8)	0.010	0.004	2.280	0.023
Ireland (mu9)	0.007	0.003	2.480	0.014
Italy (mu10)	0.002	0.003	0.850	0.395
Japan (mu11)	-0.003	0.003	-1.110	0.269
Netherlands (mu12)	0.000	0.003	0.160	0.870
New Zealand (mu13)	0.003	0.003	0.940	0.350
Norway (mu14)	0.000	0.003	0.130	0.899
Portugal (mu15)	0.003	0.003	0.860	0.388
South Korea (mu16)	0.005	0.004	1.280	0.200
Sweden (mu17)	-0.002	0.003	-0.610	0.543
Turkey (mu18)	0.017	0.006	2.880	0.004
United States (mu20)	0.003	0.003	1.180	0.240
Rho	0.907	0.017	52.900	<.0001
R-square		0.984		
Test rho=1		5.410		<.0001

*United Kingdom is a benchmark country.

[21] REG denotes number of regions.

Table 3 Kraay *et al*. (2000) database: countries and period covered for each country

Country	Code	Period	Obs.	Country	Code	Period	Obs.
East Asia and the Pacific (EAP)				**Latin American and the Caribbean (LAC)**			
China	CHN	1981-1997	17	Argentina	ARG	1966-1974, 1976-1989, 1991-1997	30
Indonesia	IDN	1966-1994	29	Bolivia	BOL	1966-1985, 1987-1997	31
Korea	KOR	1969-1997	29	Brazil	BRA	1966-1997	32
Malaysia	MYS	1976-1994	19	Chile	CHL	1967-1973, 1977-1979, 1981-1985	15
Philippines	PHL	1967-1997	31	Colombia	COL	1967-1994	28
Singapore	SGP	1966-1997	32	Costa Rica	CRI	1966-1995	30
Thailand	THA	1969-1997	29	Dominican Republic	DOM	1969-1984, 1986-1994	25
Industrial countries (INDC)				Ecuador	ECU	1966-1996	31
Australia	AUS	1966 - 1997	32	Guatemala	GTM	1966-1994	29
Austria	AUT	1967 - 1997	31	Honduras	HND	1966-1997	32
Belgium-Luxembourg	BLX	1967-1977, 1986-1996	22	Jamaica	JAM	1968-1995	28
Canada	CAN	1966 - 1997	32	Mexico	MEX	1966-1997	32
Switzerland	CHE	1983-1997	14	Nicaragua	NIC	1966-1981, 1983	17
Germany	DEU	1968-1997	30	Peru	PER	1975-1993	19
Denmark	DNK	1968-1996	29	El Salvador	SLV	1966-1997	32
Spain	ESP	1966-1997	32	Trinidad and Tobago	TTO	1974-1994	21
Finland	FIN	1966-1997	32	Uruguay	URY	1967-1973, 1980-1997	25
France	FRA	1968-1997	30	Venezuela	VEN	1974-1997	24
United Kingdom	GBR	1966-1997	32	**Middle East and North Africa (MENA)**			
Greece	GRC	1966-1996	31	Algeria	DZA	1966-1991	26
Ireland	IRL	1966-1997	32	Egypt	EGY	1988, 1989	2
Italy	ITA	1968-1997	30	Iran	IRN	1966-1982	17
Japan	JPN	1971-1986, 1991-1997	23	Israel	ISR	1969-1997	29
Netherlands	NLD	1966-1997	32	Jordan	JOR	1966-1989	24
Norway	NOR	1975-1997	23	Morocco	MAR	1966-1982, 1988-1997	27
New Zealand	NZL	1973-1997	25	Oman	OMN	1973-1989	17
Portugal	PRT	1971-1997	27	Saudi Arabia	SAU	1966-1969, 1981, 1985-1989	10
Sweden	SWE	1966-1996	31	Syria	SYR	1966-1987	21
United States	USA	1969-1997	29	Tunisia	TUN	1966-1997	32
Sub-Saharan Africa (SSA)				Turkey	TUR	1966-1998	32
Cote d'Ivoire	CIV	1970-1985, 1987	17	**South Asia (SA)**			
Cameroon	CMR	1979, 1986-1993, 1995	10	Bangladesh	BGD	1972-1981, 1983	11
Congo	COG	1993-1996	4	India	IND	1966-1997	32
Lesotho	LSO	1980-1994	15	Sri Lanka	LKA	1966-1975, 1980-1997	28
Mauritius	MUS	1974-1997	24	Pakistan	PAK	1966-1971, 1974-1997	30
Senegal	SEN	1968-1970, 1972-1981	13				
South Africa	ZAF	1968-1997	30				

Table 4 Foreign assets as share of wealth and foreign liabilities as share of capital, across regions and over time

	1966-73	1974-81	1982-89	1990-97	1966 - 97
Gross foreign assets as a share of wealth					
Industrial countries	0.076	0.088	0.152	0.211	0.148
Developing countries	0.025	0.045	0.043	0.046	0.043
East Asia and the Pacific	0.044	0.046	0.035	0.050	0.045
Latin America and the Caribbean	0.018	0.032	0.038	0.049	0.038
Middle East and North Africa	0.043	0.114	0.130	0.065	0.098
South Asia	0.007	0.011	0.008	0.012	0.010
Sub-Saharan Africa	0.096	0.061	0.054	0.056	0.061
Gross foreign liabilities as a share of capital					
Industrial countries	0.061	0.082	0.154	0.218	0.149
Developing countries	0.114	0.114	0.117	0.102	0.110
East Asia and the Pacific	0.130	0.125	0.082	0.080	0.086
Latin America and the Caribbean	0.102	0.122	0.161	0.134	0.135
Middle East and North Africa	0.186	0.136	0.171	0.161	0.160
South Asia	0.062	0.051	0.058	0.071	0.061
Sub-Saharan Africa	0.243	0.167	0.138	0.105	0.148

Weighted averages for each 8-year period are computed using unbalanced panel. For foreign assets share the weight is country wealth. For foreign liabilities share the weight is country capital.
Source: Author's calculation based on Kraay *et al*. (2000) database.

Table 5 Regression results for the model $wqhf(r)_t - wqht(r)_t = \beta(wqtf(r)_t - wqht(r)_t) + e_t$ estimated for each country

Country	Estimated β	Coeff. of auto correlation	DW	R-square	F-test β=1	F-test 1-β=1	Obs.
1	2	3	4	5	6	7	8
INDC							
AUS	1.223***	-0.648***	1.999	0.947	15.81***		31
AUT	0.425	-0.571	1.729	0.297	1.69	0.93	30
BLX	2.731*		2.323	0.145	1.29		20
CAN	1.100***	-0.446**	1.895	0.670	0.3		31
DEU	0.343	-0.760	2.141	0.573	4.00*	1.09	29
DNK	1.240***	-0.309	1.831	0.218	0.33		28
ESP	1.183***	-0.573***	1.790	0.601	1.11		31
FIN	0.703***	-0.454**	1.720	0.322	1.37		31
FRA	0.783	-0.457	1.892	0.395	0.20	2.64	29
GBR	-0.342	-0.449*	1.700	0.139	6.76**	0.44	31
GRC	1.078***	-0.523***	1.782	0.900	1.42		30
IRL	1.309*	-0.733***	1.660	0.374	0.22		31
ITA	1.024**	-0.568	1.762	0.438	0.00		29
JPN	0.291	-0.567***	1.470	0.660	4.12*	0.69	15
NLD	2.249***	-0.567***	1.503	0.322	4.17**		31
NOR	0.391**	-0.601	2.023	0.148	12.80***	5.26***	22
NZL	1.011***	-0.357*	1.983	0.793	0.01		24
PRT	0.918***	-0.523***	1.715	0.602	0.17		26
SWE	0.477	-0.567***	1.607	0.314	3.18*	2.64	30
USA	0.184	-0.768***	2.426	0.509	42.80***	2.17	28
LAC							
ARG	0.943***		1.861	0.783			27
BOL	0.841***		2.041	0.756	3.12*	86.67***	31
BRA	1.056***	-0.256	1.943	0.866	0.47		31
COL	0.949***		1.533	0.921	0.89		27
CRI	0.685***		1.653	0.227	1.74		29
DOM	1.029***		1.694	0.867	0.11		23
ECU	0.765**	-0.372**	1.883	0.751	9.90***	105.14***	31
GTM	0.938***		2.232	0.700	0.28		28
HND	0.899***		2.004	0.612	0.59		31
JAM	1.222***		1.919	0.749	2.56		27
MEX	1.065***	-0.333*	1.703	0.620	0.22		31
NIC	1.229***		2.686	0.689	1.07		15
PER	0.956***		1.540	0.801	0.14		20
SLV	1.103***		2.147	0.677	0.55		31
TTO	0.916***		1.862	0.875	1.12		20
URY	0.865***		1.877	0.787	1.97		23

(Continued)

Table 5 Regression results for the model $wqhf(r)_t - wqht(r)_t = \beta(wqtf(r)_t - wqht(r)_t) + e_t$ estimated for each country (Contd)

Country	Estimated β	Coeff. of auto correlation	DW	R-square	F-test β=1	F-test 1-β=1	Obs.
1	2	3	4	5	6	7	8
EAP							
CHN	1.141***	-0.606**	2.044	0.781	1.02		16
IDN	0.997***		1.784	0.999	0.58		28
KOR	0.901***	-0.367*	1.835	0.614	1.27		28
MYS	0.610**		1.566	0.424	5.10**		18
PHL	0.884***	-0.337*	1.660	0.283	2.12		30
SGP	0.162	-0.385*	1.713	0.112	6.56**	0.25	31
THA	0.653***		1.777	0.654	14.44***	51.12***	28
MENA							
DZA	1.035***	-0.285	1.883	0.829	0.15		25
IRN	0.975***	-0.497*	1.213	0.974	0.37		16
ISR	1.037***		1.635	0.366	0.02		28
JOR	0.494*		1.548	0.152	4.12*	3.96*	23
MAR	0.449***		2.020	0.377	21.78***	14.51***	25
OMN	0.741***		1.236	0.393	1.19		16
SYR	0.926***	-0.280	1.905	0.927	1.34		20
TUN	0.905***	-0.288	1.87	0.739	0.80		31
TUR	0.811***		2.038	0.677	3.42*		31
SA							
IND	1.020***	-0.465***	1.898	0.947	0.17		31
LKA	0.688***		1.791	0.548	6.21**		26
PAK	1.019***		2.085	0.888	0.08		28
SSA							
CIV	0.788**		2.298	0.378	0.61		15
MUS	0.624***		1.642	0.683	17.28***		23
ZAF	1.294***	-0.770***	1.516	0.586	1.77		29

***, ** and * denote significance levels at 0.01, 0.05 and 0.1, respectively.
The estimation method is ordinary least square. Where it is necessary, we corrected for first order autocorrelation and used full unconditional maximum likelihood estimation method. Since there is no intercept term used, the R-square is redefined. In column 7 the F-test is reported only 1) to see if $\alpha = 1 - \beta$ is different from 1 in the cases when coefficient β is not different from zero; and 2) to see if $\alpha = 1 - \beta$ is different from 1 in the cases when β is different from zero, but in the same time less than one.

Table 6 Regression Result for Each Region and Overall Panel

Region	Estimated β	R-square	F-test β=1	Number of Countries	Obs
1	2	3	4	5	6
Assuming cross – sectional correlation					
INDC	0.948***	0.907	9.767***	17	340
EAP	0.970***	0.825	0.463	5	100
LAC	0.884***	0.839	19.742***	11	220
MENA	0.772***	0.545	6.082**	3	60
SA	1.108***	0.943	0.205	2	40
SSA	0.653***	0.656	21.000***	2	40
Assuming cross – sectional independence					
INDC	0.996***		0.693	17	340
EAP	0.956***		0.796	5	100
LAC	0.920***		4.296**	11	220
MENA	0.732***		8.366***	3	60
SA	1.021***		0.269	2	40
SSA	0.676***		13.925***	2	40
		0.730			
All	0.947***	0.716	6.364**	40	800

***, ** and * denote significance levels at 0.01, 0.05 and 0.1, respectively.

Table 7 Rigidity parameters in GDyn model

Country	Estimated β	F-test β=1	F-test 1-β=1	*RIGWQH*	*RIGWQ_F*
1	2	3	4	5	6
			INDC		
AUS	1.223***	15.81***		0.01	1
AUT	0.425	1.69	0.93	1	1
BLX	2.731*	1.29		0.01	1
CAN	1.100***	0.3		0.01	1
DEU	0.343	4.00*	1.09	1	0.01
DNK	1.240***	0.33		0.01	1
ESP	1.183***	1.11		0.01	1
FIN	0.703***	1.37		0.01	1
FRA	0.783	0.20	2.64	1	1
GBR	-0.342	6.76**	0.44	1	0.01
GRC	1.078***	1.42		0.01	1
IRL	1.309*	0.22		0.01	1
ITA	1.024**	0.00		0.01	1
JPN	0.291	4.12*	0.69	1	0.01
NLD	2.249***	4.17**		0.01	1
NOR	0.391**	12.80***	5.26***	1	1
NZL	1.011***	0.01		0.01	1
PRT	0.918***	0.17		0.01	1
SWE	0.477	3.18*	2.64	1	0.01
USA	0.184	42.80***	2.17	1	0.01
ALL INDC	0.948***	9.767***	3278.64***	0.05	1
			LAC		
ARG	0.943***			0.01	1
BOL	0.841***	3.12*	86.67***	0.189	1
BRA	1.056***	0.47		0.01	1
COL	0.949***	0.89		0.01	1
CRI	0.685***	1.74		0.01	1
DOM	1.029***	0.11		0.01	1
ECU	0.765**	9.90***	105.14***	0.307	1
GTM	0.938***	0.28		0.01	1
HND	0.899***	0.59		0.01	1
JAM	1.222***	2.56		0.01	1
MEX	1.065***	0.22		0.01	1
NIC	1.229***	1.07		0.01	1
PER	0.956***	0.14		0.01	1
SLV	1.103***	0.55		0.01	1
TTO	0.916***	1.12		0.01	1
URY	0.865***	1.97		0.01	1
ALL LAC	0.884***	19.74***	1143.07***	0.13	1

(Continued)

Table 7 Rigidity parameters in GDyn model (Contd)

Country	Estimated β	F-test β=1	F-test 1-β=1	*RIGWQH*	*RIGWQ_F*
1	2	3	4	5	6
			EAP		
CHN	1.141***	1.02		0.01	1
IDN	0.997***	0.58		0.01	1
KOR	0.901***	1.27		0.01	1
MYS	0.610**	5.10**		1	1
PHL	0.884***	2.12		0.01	1
SGP	0.162	6.56**	0.25	1	0.01
THA	0.653***	14.44***	51.12***	1	1
ALL EAP	0.970***	0.463	468.93***	0.01	1
			MENA		
DZA	1.035***	0.15		0.01	1
IRN	0.975***	0.37		0.01	1
ISR	1.037***	0.02		0.01	1
JOR	0.494*	4.12*	3.96*	1	1
MAR	0.449***	21.78***	14.51***	1	1
OMN	0.910***	0.14		0.01	1
SYR	0.926***	1.34		0.01	1
TUN	0.905***	0.80		0.01	1
TUR	0.811***	3.42*		0.233	1
			SA		
IND	1.020***	0.17		0.01	1
LKA	0.688***	6.21**		1	1
PAK	1.019***	0.08		0.01	1
			SSA		
CIV	0.788**	0.61		0.01	1
MUS	0.624***	17.28***		1	1
ZAF	1.294***	1.77		0.01	1
ALL	0.947***	6.364**	1996.26***	0.06	1

***, ** and * denote significance levels at 0.01, 0.05 and 0.1, respectively.