

Meltrade Model – progress update

Macro Elasticity Link Trade Model

The model has National Accounts data for 70 countries and 9 regions and trade data for five SITC categories and three sub-categories. It follows the structure of the original Project LINK model. Previously the Meltrade model was constructed using a limited data set, consisting of Project LINK output data. This was used to build a “proof of concept” model. It was able to project the data to 2050.

The model was user operable, using a suite server-side of programs to select and display data. These operate through a browser interface, enabled by a local host server emulator. This can still be used.

All data have now been downloaded, updated, and the model equations estimated. Numerous data anomalies have been overcome, and coding improvements made. The model is again able to project to 2050.

Data sources

National accounts data can be downloaded from the [United Nations Department of Economic and Social Affairs](#). These are provided in four forms: national currency, real and nominal, and US dollars, real and nominal. These are provided for over 200 countries. For individual countries, the national currency data are downloaded. For regions, the US dollar data are downloaded and aggregated. The UN data do not include Taiwan for “political reasons”. These data must be downloaded from the [Taiwan Statistical Bureau](#).

Trade data is available from [UN Comtrade](#). They include imports and exports by SITC group by country in \$USbn. These data were once freely available but now access has been greatly restricted. Most series must be downloaded piecemeal. This is particularly laborious if seeking a trade flow matrix. After download, countries are aggregated into regions as required.

Other sources include the IMF, ILO and the World Bank. For energy related data, the best source is the [US Energy Information Administration](#). Quantity data on production, consumption, imports, exports, reserves and emissions, are provided for coal, gas and oil for over 200 countries. These are aggregated into the appropriate regions as required.

For details of the countries included in the regions see Appendix A.

Model equations

All behavioural equations are formulated in rate-of-change terms. This has the advantage that all the coefficients are readily explicable: they are elasticities. The equations capture long term trends, as required for a long term model.

The data have been exported to TSP for estimation in a combined cross-section – time series form. The elasticities are assumed constant for all countries. The “constant” terms are specific to each country and represent the residual rate of change that is not explained by the other variables.

For estimation precision and computational integrity, it is necessary to distinguish between countries where import demands are primarily determined by domestic needs, and others that act as trans-shipment ports, such as Hong Kong and Singapore, where imports are mainly re-exported to

more local destinations. Based on the value of imports and exports relative to GDP, a “trans-shipment factor”, between 0 and 1, is calculated for each country and this is used in the estimation process.

For details of the estimated equations see Appendix B. The estimation period is 2003-2018.

Exports

Previously a 79 x 79 trade flow matrix had been estimated for 1996. A detailed trade flow matrix for 2021, for 8 commodity categories has been obtained from Comtrade data. This has been used to interpolate a trade flow matrix for each year of the historical period using the RAS row/column ratio adjustment system, on the assumption that total world imports equals (or closely approximates) total world exports.

A projection equation has been estimated for each cell of the matrix based on an imputed capital/output ratio, on the grounds that a country needs to have a degree of historical investment in order to develop an export capability. In the forecast period, the matrix is recalibrated based on the previous year’s import and export solutions.

Having determined imports by country from the demand equations, export supply from each country is obtained by application of the trade flow matrix for each commodity.

Computational procedure

In a global model “everything” is endogenous. This has an advantage in being a closed system, but presents computational challenges in achieving stability. Fortunately there many are checks and balances that can be imposed to ensure the mutual integrity of the results. Total world supply and demand should match, as should total world imports and exports. For commodities, within a country, production plus imports should equal consumption plus exports.

Commodity prices are effectively exogenous, being set to a long term growth path. Other parameters that enable expert input, are imposed exogenously, and can be set by the user.

Population is exogenous but barely used at present. However this will change, see below. The following is an outline of the computer code, as per the SOLVEGDP module.

- Nominal GDP computed from components: $Y=C+I+G+X-M$
- Real GDP computed from components: $Y=C+I+G+X-M$
- GDP deflators computed as the ratio of nominal to real
- Real GDP components are computed from equations
 - Consumption
 - Investment
 - Government spending
 - Imports of goods
 - Imports of services
 - Imports of goods and services: sum
- Nominal imports of goods and services: imports deflator
- Nominal US\$ imports by SITC: equations: SITC 0+1, 2+4, 5-9
- Nominal US\$ imports by fuel: equations: coal, oil & gas
- Nominal US\$ imports by SITC 3 : sum of coal oil & gas
- Nominal US\$ imports, all goods: sum SITC 0-9
 - Nominal imports of goods in domestic currency: exchange rate
 - Real imports goods: nominal/deflator
- Nominal US\$ exports determined from imports via trade flow matrix: 8 commodities

- REBALANCE module: adjust exports if country anomalies
- Export deflators: equations
- Coal: real disposition
 - Coal production: growth parameter linked to GDP with reserve depletion factor
 - Coal consumption:: growth parameter linked to GDP with greenhouse gas reduction factor
 - Reserves: depleted by production
 - PRODCON module: world coal production matched to world coal consumption
 - Coal imports and exports linked to nominal
 - RESOLVE module by country: coal production + imports = consumption + exports
- Oil: real disposition
 - Crude production: growth parameter linked to GDP with reserve depletion factor
 - Refined production: growth parameter linked to GDP with greenhouse gas reduction factor
 - Crude consumption:: equivalent to refined production
 - Refined consumption:: growth parameter linked to GDP with greenhouse gas reduction factor
 - Crude reserves: depleted by production
 - PRODCON module: world crude production matched to world crude consumption
 - PRODCON module: world refined production matched to world refined consumption
 - Real oil imports and exports linked to nominal
 - RESOLVE module by country: crude production + imports = consumption + exports
 - RESOLVE module by country: refined production + imports = consumption + exports
- Gas: real disposition
 - Production: growth parameter linked to GDP with reserve depletion factor
 - Consumption:: growth parameter linked to GDP with greenhouse gas reduction factor
 - Reserves: depleted by production
 - PRODCON module: world gas production matched to world gas consumption
 - Gas imports and exports linked to nominal
 - RESOLVE module by country: gas production + imports = consumption + exports
- Nominal US\$ imports and exports of coal, oil and gas linked back to revised real estimates
- Local currency imports and exports linked back to US\$ estimates
- Other equations: wage rates, interest rates, exchange rates

Population

UN provides demographic data for over 200 countries including population by age and sex, fertility and death rates. It also provides long term projections of these data. Fertility and death profiles by country can be linked to per-capita income by country. In a combined economic and population model, the economic model can provide per-capita incomes, and the population model can provide key population projections. These, together with per-capita GDP projections, can form the basis of long term GDP growth projections per country.

At present however, the UN population projections are utilised exogenously. Real per capita income growth is determined by the level of real \$US per capita income and the proportion of the population aged 20-59 (see Appendix B). Countries with low per capita income and a high proportion of working age population achieve higher growth rates.

In this way long term real GDPs are linked to population. Since these are already determined by the real GDP identities, the non-trade components of GDP are adjusted to reconcile the GDP estimates.

Climate model

The consumption of coal, oil and gas largely determines CO₂ emissions. Atmospheric CO₂ concentration is closely correlated with global temperature rise. Historical measurements of atmospheric CO₂ concentration, compared with emissions, provides a measure of planetary CO₂ absorption. Absorption is highly correlated with atmospheric concentration. A model of land and sea absorption and emissions has been developed. [See A Macro Time Series Model of the Carbon Cycle](#). This enables the projection of atmospheric CO₂ concentration and global temperature rise.

Overlay of IMF projections

The IMF, in its regular World Economic Outlook releases, provides a comprehensive data set for around 200 countries. The IMF updated and forecast data for real GDP are used to project the model data forward.

Further developments of the model

The UN data for GDP by country also provides value added by industry, uniformly for 7 sectors. Conceivably, these could be used to impute input-output tables. More amenably, this information could be used to gauge measures of productivity.

Appendix A - Regions

Of the 79 countries and regions, there are 70 individual countries and nine regions as follows:

Region	No. of countries	Major or most developed countries
Africa Least Developed	30	Madagascar, Mali, Mozambique, Democratic Republic of Congo. Zambia, Uganda, Tanzania, Madagascar, Côte d'Ivoire
Caribbean and Central America	26	Jamaica, Honduras, Trinidad & Tobago, El Salvador, Panama, Costa Rica, Guatemala, Dominican Republic, Cuba
Other African Countries	12	Mauritius, Congo, Namibia, Equatorial Guinea, Senegal, Botswana, Gabon, Cameroon. Angola
Other Europe	12	Georgia, Albania, Estonia, ,Cyprus, Latvia, Lithuania, Belarus.
Other South East Asia	17	Fiji, Papua New Guinea, Brunei, Myanmar, Sri Lanka
Other West Asia Oil Exporting Countries	8	Yemen, Azerbaijan, Oman, Syria, Kazakhstan, United Arab Emirates.
South East Asia Least Developed.	4	Laos, Cambodia, North Korea, Vietnam
West Asia Oil Importers.	13	Afghanistan, Nepal, Turkmenistan, Jordan, Uzbekistan, Lebanon, Bangladesh
Former Yugoslavia	7	Macedonia, Bosnia & Herzegovina, Serbia, Slovenia, Croatia

Appendix B – Model equations

Coefficient	Variable	Equation	t value
	ce	Real consumption expenditure	
0.140	(w/p)	Real wages	3.30
-0.040	(r-r _a)	interest rate (difference from average)	-1.06
0.730	gdp	GDP	37.12

0.310	m	imports	6.45
0.135	g _i	average residual cons rate, all countries -4.41 5.67 (min, max)	
	inv	Real investment	
0.830	gdp	GDP growth	1.70
0.150	gdp ₋₁	GDP growth, lagged	0.31
2.890	pop	Population growth	1.02
-1.670	pop ₋₁	Population growth, lagged	-0.60
-0.070	(r-r _a)	interest rate (difference from average)	-0.08
0.205	g _i	average residual investment rate, all countries -3.87 7.69 (min, max)	
	gov	Real government spending	
0.650	gdp	GDP growth	8.94
1.070	pop	Population growth	2.77
0.007	g _i	average residual rate for G/Y, all countries -6.09 10.00 (min, max)	
	mg	Real imports - goods	
0.330	xy	(trans-shipment factor GDP	8.71
1.000	xnt	non-trans-shipment factor) exports	*
-0.300	mp	import prices	
0.223	g _i	average residual import goods rate, all count -2.12 1.27 (min, max)	
	ms	Real imports - services	
0.470	y	GDP	6.73
-0.300	mp	import prices	
2.240	g _i	average residual import services, all count -8.78 10.00 (min, max)	
	pd	Consumption deflators	
0.240	w	Wages	12.50
0.200	mp	import prices	
2.795	g _i	average residual consumption deflator rate, all countries -0.63 10.00 (min, max)	
	pi	Investment deflators	
0.290	w	Wages	5.27
0.030	mp	import prices	0.66
2.219	g _i	average residual investment deflator rate, all countries -2.48 10.00 (min, max)	
	pg	Government expenditure deflators	
0.200	w	Wages	
0.870	pc	consumption prices	23.78
0.626	g _i	average residual govt deflator rate, all countries -5.09 10.00 (min, max)	
	pm	Import deflators	
0.130	pt	traded goods prices (country SITC weight)	5.05
0.200	xr	exchange rate (local/\$US)	14.00
5.606	g _i	average residual import deflator rate, all countries -1.60 10.00 (min, max)	
	m ₀₁	Imports, SITC 0-1 (food and beverages)	
0.295	xy	(trans-shipment factor) GDP	7.08
1.000	xnt	(x non-trans-shipment factor) Exports	*
-0.316	rp	relative price SITC 0-1	-9.73
4.718	g _i	average residual import share -3.69 10.00 (min, max)	

	m ₂₄	Imports, SITC 2-4 (raw materials)	
0.379	xy	(trans-shipment factor) GDP	7.59
1.000	xnt	(non-trans-shipment factor) Exports	*
-0.389	rp	relative price SITC 2-4	-9.97
3.081	gi	average residual import share -6.69 6.51 (min, max)	
	m ₃	Imports, SITC 3 (fuels)	
0.289	xy	(trans-shipment factor) GDP	4.71
1.000	xnt	(non-trans-shipment factor) Exports	*
-0.465	rp	rel price SITC 3	-10.20
4.197	gi	average residual import share -7.07 10.00 (min, max)	
	m ₅₉	Imports, SITC 5-9 (manufactured goods)	
0.437	xy	(trans-shipment factor) GDP	3
1.000	xnt	(non-trans-shipment factor) Exports	*
-0.262	rp	relative price SITC 5-9	-8.12
3.601	gi	average residual import share -5.27 7.33 (min, max)	
	m _{coal}	Imports, Coal (of SITC 3)	
0.366	xy	(trans-shipment factor) GDP	6.25
1.000	xnt	(non-trans-shipment factor) Exports	*
-0.419	rp	rel price SITC 3	-9.18
3.452	gi	average residual import rate -9.00 10.00 (min, max)	
	m _{oil}	Imports, Oil (of SITC 3)	
0.274	xy	(trans-shipment factor) GDP	4.45
1.000	xnt	(non-trans-shipment factor) Exports	*
-0.487	rp	rel price SITC 3	-10.69
4.215	gi	average residual import rate -9.00 10.00 (min, max)	
	m _{gas}	Imports, Gas (of SITC 3)	
0.222	xy	(trans-shipment factor) GDP	3.55
1.000	xnt	(non-trans-shipment factor) exports	*
-0.280	rp	relative price SITC 3	-5.74
4.890	gi	average residual import rate -6.35 10.00 (min, max)	
	px	Export deflators	
0.672	P	domestic prices	14.85
0.500	pp	traded goods prices (country SITC weight)	*
0.062	xr	exchange rate (local/\$US)	2.18
0.785	gi	average residual export deflator rate, all countries -5.73 7.58 (min, max)	
	w	Wage rates	
0.538	p	domestic prices	13.72
3.706	gi	average residual wage inflation rate, all countries -9.00 10.00 (min, max)	
	r	Interest rate - deviation from average 2	
0.151	p	domestic prices (above 3%)	6.49
0.041	xr	exchange rate (local/\$US) (above 5%)	1.71
0.187	gi	average residual interest rate, all countries -1.98 0.66 (min, max)	
	xr	Exchange rate (local currency/\$US)	
0.592	rp	domestic prices - world prices	14.01
-0.111	ir	interest rate – average (2003,2008)	-2.04
-0.083	bp	balance of payments percent GDP, lagged	-2.72
-1.942	gi	average residual exchange rate, all countries -9.00 2.73 (min, max)	
	rpcy	Real per capita income growth	

-0.036	usdy	per capita income (\$US/year)	-4.25
5.557	pwa	population proportion age 20-59)	11.82
-0.036	gi	average residual exchange rate, all countries (min.max)	-9.00 5.29

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