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Multicountry and Regional Macroeconometric Models

Abstract

Multicountry models were developed in the previous century to serve the analyses and projections of the world economy and/or its regions (for instance Latin America). They distinguish the largest countries and the rest of the world (ROW) composed of particular countries. Hence, their structure is based on the specifications of equations for individual countries using full statistical information available at the countries level.

The regional macroeconomic models are built for either administrative or geographical units distinguished within large countries (USA, China, Russia). Their structure should be in principle similar to those of the national economy. However, the statistical information of the regional economies is typically uncomplete: no sufficient information is available on exports and imports of the region, migrations and financial flows. Appropriate approximations are necessary. As in majority of countries the prices and wages movements are in general unified over the country, the variables representing the national level excerpt an impact on the regional variables. The regional impact on the national variables is rather unusual.

The paper shows the skeleton model applied in the multicountry models and the skeleton of the macroeconomic regional model. The specific properties of the regional model are discussed and the possibilities of its extensions analysed.

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1. Introduction

The development of macro econometric national models and regional models has a long tradition. The use of national models in testing the economic theories and in policy simulations and analyses and economic forecasting was over the last 50 years successful. It lead in the 70-ties to a tendency the leading modelling centers to model the surrounding world i.e. to construct multicountry models. It became the domain of international organisations and also public research centers and of national banks. The multicountry models are composed of a sample of national models mostly linked via commodity flows. Their structure developed along the national models being their components. We shall briefly comment on this process in the next paragraph[1].

On the other extreme, the tendency evolved to analyse the development of particular regions, especially of large countries as the USA both to support the regional science, the local policies and also local forecasting. Here, we constrain the discussion to the building of regional models in a narrow sense, as of models explaining the relationships within the first subdivision of the country i.e. region like California, Lyon (France) Poznań voirodship (Poland). The generalization to lower units like metropolitan areas will be skipped. If the models cover all regions within a country this system is called a multiregional model.

The structure of the regional model should in principle be similar to the structure of national models, following L.R. Klein (1969) suggestions. It shows up specific properties, however, because of special "regional" characteristics and mainly because the regional data bases are not sufficient enough to construct many equations in a similar way as in the national models. This will be the subject of discussions presented in paragraph 3.

2. The multicountry econometric models.

The origins are to be found in the Project LINK, that was developed in Philadelphia in the early 70-ties by the LINK center, led by L.R. Klein. The Project LINK grew enormously from 7 to above 100 countries from 1987. The national models had different structure being elaborated by national units

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[1] The multicountry models contain mainly national models of the major countries. The models of remaining countries representing either particular regions (groups of countries, like LATIN America) or the rest of the world (ROW), built according to similar principles for the regions as a whole or using the bottom-up principle. Notice, that "region" is understood here as a summary characteristics for countries (nations).

(annual and quarterly). All were interlinked by commodity flows (4 groups). To achieve it a matrix of export shares in international trade was estimated and systematically updated (Hickman 1991). From 1971-72 the model LINK was systematically used in forecasting world economy and in policy scenario analyses. In the last decade it came over to the Toronto University and to the United Nations in New York.

This development was followed by a construction of multicountry models in international organisations and central banks. These models were composed of national models constructed at the particular institutions using the same specifications. They were elaborated for large countries and simplified for small countries. Let us mention the OECD INTERLINK model (Richardson 1988), World Bank models and IMF MULTIMOD models, mainly used is simulation excercisens (Laxton et al. 2004), European Commission QUEST (Roeger, in't Veld 1997).

The development of multicountry models in large countries led to the process of combining the national models with the world models. Let us mentions the FRB/WORLD model, that included the FRB/MCM model for the USA economy (Levin et al. 1999). At the Bundesbank the MEMOD multicounty model, was constructed 2000. At the National Institute of Economic and Social Research (NIESR London) a quarterly world model GEM was constructed in the 80-ties. Its new version NIGEM contained the quarterly model for the UK as well as for the OECD countries and 15 other countries and groups of countries (2005). French model MIMOSA contained also France and world economy and was fairly disaggregated (Delessy et al. 1996).

We also have to mention the enormous FUGI annual model by A. Onisbi that included over 150 000 equations (180 countries), specifying both demand and supply of products (1993). On the other extreme, we have to indicate the model MC of the world economy by R.C. Fair 2004), that included 39 countries. It was used in many interesting policy simulations.

The structure of the above models is not unique and it changed in time following the developments in national model building, like incorporation of rational expectations in several models, emphasis on the microeconometric underpinning of equations and in the last years relying more intensively on economic theory, developed within the Dynamic Stochastic General Equilibrium (DSGE) models (cf. W. Welfe 2010).

Below a skeleton structure of a country model is shown

Accounting identity

$$X_t = C_t + J_t + G_t + \Delta R_t + E_t - M_t \tag{1}$$

Equations explaining final demand

Consumer demand

$$C_t = c(H, V_t r_t), \tag{2}$$

Investment demand

$$J_t = j(X_t, r_t w_t / p_t^s), \tag{3}$$

Inventory increase

$$\Delta R_t = r(X_t wx_t), \tag{4}$$

Imports

$$M_t = m(X_t, wx_t, p_t / e_t p_t^w) \tag{5}$$

Exports

$$E_t = e(WT_t, wx_t, p_t / e_t p_t^w). \tag{6}$$

Consumption depends on expected income H_t, personal assets, V_t and interest rate r_t. Investment depends on GDP (X_t), user costs represented by interest rate r_t and relation of wages (w_t) and capital prices (p_t^s). The inventory increase depends on GDP (X_t) and indicator of market tensions (wx_t). In the foreign trade equations the relative prices and the rate of capacity utilization (wx_t) are present except for the demand variables like GDP and world trade (WT_t).

Equations explaining supply sector:

Employment

$$N_t = n(X_t, N_{t-1}, A_t),$$ (7)

Real wages

$$w_t / p_t = w(u_t, \pi_t, tw_t),$$ (8)

Producer prices

$$p_t = p(wx_t, w_t / \pi_t, ep^w),$$ (9)

Exchange rate

$$e_t = e(e_t^e, r_t / r_{t,}^w \gamma)$$ (10)

Employment is obtained from inverting the production function, hence, it depends on GDP (X_t) and total factor productivity (A_t). Real wages change as a result of negotiations and depend on the unemployment rate (u_t), labour productivity (π_t) and income tax (tw_t). Producer prices depend on labour costs, (w_t / π_t) world prices (p_t^w) and market tensions (wx_t). The exchange rate depends on its expected value, ratio of domestic and foreign interest rates (UIP) and risk premium (γ).

Equations explaining financial sector:

Budget income

$$BP_t = b(tw_t YP_t, ta_t AP_t, tv(CP_t + GP_t)),$$ (11)

Budget deficit

$$BD_t = BP_t - BC_t,$$ (12)

Money demand

$$MD_t = m(Y_t, \Delta Y_t, P_t, r_t),$$ (13)

Interest rate

$$r_t = r(P_t - P_{t-1}) / P_{t-1}$$ (14)

The budget revenues are mainly determined by inflows from taxes – direct taxes on personal income (YP_t), on corporate incomes (AP_t) and indirect taxes – the tax base being sales of consumer goods $(CP_t + GP_t)$. The budget deficit is commonly obtained as a residual by subtracting budget expenditures (BC_t) from budget income. Money supply equals money demand being dependent on personal incomes and their increase, prices and interest rates. Interest rates if they are endogenous are determined following the rate of inflation.

The above stylised equations represent long-term relations. In the short-run the adjustments are introduced, either in the from of lags and leads. The expectations are in many models introduced – there are either rational expectations or adaptive expectations.

3. The regional models

The econometric regional model developed mainly in the USA in the 60's and 70's under the influence of national modellers (cf. Bolton 1991) . Later their construction served the needs of regional science and specific tasks of regional governments. Their development was constraint by the lack of regional data in many areas, like commodity and money flows from and to particular regions, migrations etc.

These development were followed by similar research in France, where R. Courbis has built the REGINA model for France (Courbis 1979), for Europe and Japan by B. Issaev et al. (1982) for Canada by R. Bolton (1982), and for Spain: Castilla La Mancha (Montero et al 2008).

The majority of models are econometric models for single region. Multiregional models are seldom built. The single regions models are linked to the national models such that several national variables are introduced into the regional models (being thus exogenous). This is so called "top-down" approach. The reverse links ("bottom-up") are rather-seldom-for instance they may express the role of fuel output exported to the whole country. The links between single regions were poorly emphasised.

Following the research and administrative goals the single region models were substantially disaggregated; many sectors were distinguished. The national models to be linked with them had to show a similar level of sectoral disaggregation – they were large macroeconometric models like Wharton or DRI for the US economy – in contrast to the multicountry models being manly one sectoral.

The structure of the single regional models could not fully follow the Klein's suggestions, mainly because of the scarcity of data as regards the regional accounts. The Gross Regional Product (GRP) and its decomposition similar to (1) was available in annual terms and only rarely presented a time series. No quarterly data was typically available.

Several proxies were used instead. Retail sales (in constant prices) were applied instead of private consumption. Private investment was not always available. The residential building was representing the residential investment expenditures. The regional exports and imports were in general not accessible. The demand for output was represented by either gross output $\left(Q_t^R\right)$ or value added $\left(X_t^R\right)$ decomposed by industries (mainly manufacturing). Similar decomposition was available for employment $\left(N_t^R\right)$, rather than working hours $\left(H_t^R\right)$. The capital stock $\left(K_t^R\right)$ was hardly available and its increase was approximated by investments. That in exceptional cases lead to the construction of potential output using either Cobb-Douglas or CES production functions. Estimates of labour supply became available after allowing for unemployment rates and migration. The producer prices were rather national, whereas the CPI regionally distinguished. The nominal and real wages were in principle observable and hence the calculation of nominal and real personal income $\left(Y^R\right)$ feasible. The financial flows were in principle limited to regional budgets.

This concise characteristic of the regional data base makes possible to demonstrate a skeleton structure of a single regional model. It will be partly illustrated by the structure applied for an econometric model of the Łódź – region in Poland[2].

The skeleton econometric for a single region

Final demand:

Real retail sales

$$S_{tj}^R = s\left(Y_t^R, P_{tj}^R / P_t^R\right), \tag{15}$$

Business investment

$$J_{ti}^R = j\left(Q_{ti}^R, J_{ti}, r_t\right), \tag{16}$$

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[2] See Florczak et. al. 2008. A model for Mazowsze region was recently announced. The paper by Florczak 2011 is, however, very general and does not contain any information on the models structure.

Residential investment

$$JR_t^R = j\left(Y_t^R, r_t\right), \tag{17}$$

The consumer demand being represented by retail sales depends on regional real disposable income $\left(Y_t^R\right)$ and relative prices of distinguished commodity and services groups. Similar factors affect residential investment. The business investment by industries if available, depends on their output, the national investment and the national interest rate.

Supply sector:

Regional gross output

$$Q_{ti}^R = q\left(Q_{ti}, S_t^R, J_{ti}^R\right), \tag{18}$$

Regional value added

$$X_{ti}^R = x\left(Q_{ti}^R, X_{ti}\right), \tag{19}$$

Potential output

$$\Delta X_{ti}^{RO} = x\left(J_{ti}^R, \Delta N_{ti}^R, \Delta TFP_{ti}^R\right), \tag{20}$$

Employment

$$N_{ti}^R = n\left(X_{ti}^R N_{t-1,i}^R, N_{ti}\right), \tag{21}$$

Real wages

$$w_{ti}^R / pc_t^R = w\left(\mu_t^R, \pi_{ti}^R, w_{ti} / p_t\right), \tag{22}$$

Producer prices

$$p_{ti}^R = p\left(p_{ti}\right), \tag{23}$$

Consumer prices

$$pc_{ti}^R = p\left(pc_{ti}, p_{ti}^R\right). \tag{24}$$

The regional gross output by industries depends on local consumer and investment demand and also on national output. Gross output is transferred into value added (by industries), sometimes using I-O coefficients. The output determines employment with some lags. Potential output can be obtained using production function and allowing for TFP increase, being dependent on R&D

local expenditures. Real wages are affected by local factors: the unemployment rate $\left(\mu_t^R\right)$ and productivity $\left(\pi_{ti}^R\right)$ and are influenced by the nation- wide dynamics of wages. Producer prices do not differ from national-wide prices, whereas consumer prices are affected by national-wide prices and regional producer prices.

The financial flows description is mainly constrained to the local budget receipts and expenditures. The equations do not differ much from the nation-wide shown above.

4. Conclusions

The above review is by no means very simplified. It however, allows to draw the conclusion that as the multicounty models are forrunners in developing the structure of macromodels following the most recent contributions of economic theory, the regional models follow these development with certain lags. Main reason remains the scarcity of data, especially dealing with inter regional commodity flows and also migrations.

Nevertheless a serious progress has been made in construction of econometric regional models. It has to be stressed that there were more or less clear lines drown between relations that have specific, "regional" character and relations that are national wide (wages, prices, interest rates), that can be implemented into regional models.

The development of data bases in the last years is so quick, that it may be expected a further decline of existing gaps in the structures of nation wide and sectoral models, that might bring more common construction of multiregional models.

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Streszczenie

MAKROEKONOMETRYCZNE MODELE GOSPODARKI ŚWIATOWEJ I MODELE REGIONALNE

Modele gospodarki światowej lub jej części (regionów) zostały zbudowane w ubiegłym stuleciu, służąc celom analizy rozwoju i prognozowaniu gospodarki całego świata lub wyróżnionych regionów (np. Ameryki Łacińskiej). Modele te zwykle wyróżniały największe, uprzemysłowione kraje świata oraz sumarycznie pozostałe kraje (ROW). Stąd ich struktura została oparta na specyfikacjach równań typowych dla poszczególnych krajów, wykorzystując pełnię statystycznych informacji gromadzonych dla każdego kraju.

Makroekonometryczne modele regionalne są budowane albo dla wyróżnionych jednostek administracyjnych albo geograficznych w obrębie na ogół dużych krajów (USA, Chiny, Rosja, etc.). Ich struktura winna być zbliżona do struktury modeli danych krajów. Jednakże, dane statystyczne dotyczące regionów są na ogół niekompletne: brak jest danych o eksporcie i imporcie regionu, migracjach ludności, przepływach finansowych etc.. Wymaga to odpowiednich aproksymacji. Ponieważ w wielu krajach dynamika cen i plac przebiega w sposób podobny w skali kraju – wprowadza się do modeli regionalnych zmienne dotyczące całego kraju. Z drugiej strony oddziaływanie zwrotne występuje na ogół rzadko w tych modelach.

W referacie przedstawiono typowe struktury makroekonometrycznych modeli występujących w modelach gospodarki światowej oraz struktury modeli charakterystyczne dla modeli regionalnych. Specyficzne własności modeli regionalnych są przedmiotem odrębnej dyskusji a także możliwości rozbudowy tych modeli są analizowane.