

ANNEX D

Main Models of the New Economic Geography

Krugman's 1991 model includes two *a priori* identical regions in endowment factors; two factors of production – agriculture with its constant-returns tied to the land, and manufacturers with increasing-returns (though a monopolistic Dixit-Stiglitz model) – that can be located in each region; and transportation costs for manufacturing goods. Workers are mobile across regions. The model finds that as transportation costs decrease and economies of large-scale production are present, a region with a relatively large non-rural population (or larger initial production) will be an attractive place to produce because of the large local market and because of the availability of goods and services produced there. This will attract more people increasing local demand and profits and attracting more firms. The forces of agglomeration depend on the level of trade cost and the proportion of mobile population in response to wage differentials. The external economies are pecuniary (not technological), arising from the desirability of selling to and buying from a region in which other producers are concentrated.

Krugman extends his 1991 model to examine equilibrium locations in continuous space. This model (1993), built with the same assumptions as the 1991 model, is geared for explaining the formation of metropolitan centres. The analysis finds that agglomeration holds population concentration together and allows this concentration to occur in a variety of possible sites. Thus there are multiple equilibria for a metropolitan location.

Krugman and Venables (1995) drop the assumption of labour mobility. This model contains two economies (regions) identical in endowment preferences and technology, and two factors of production: agriculture and manufacturing. The manufacturing sector has monopolistic increasing returns to scale (Dixit-Stiglitz) and produces final goods as well as intermediate goods. The manufacturing sector has constant returns. The model assumes transportation costs. At high transportation costs all regions have the same manufacturing production. When transportation costs fall

below a critical value the region with the larger (initial) manufacturing share will attract more firms due to forward and backward industrial linkages:

- Producers of final goods will find larger industrial concentration more attractive because there is a larger base of intermediate producers, giving rise to forward (cost) linkages.
- Producers of intermediate goods will find it advantageous to produce near the large final good industry, giving rise to backward (demand) linkages.

These forward and backward linkages will increase the real income of the core region relative to the periphery. If costs, however, continue to fall further, the wage differential will induce firms to relocate back to peripheral regions.

In **Venables (1996)** each economy has three sectors. The first sector (perfectly competitive) produces a tradeable good. The other two are monopolistically competitive and vertically linked, one providing an intermediate good to the other. Each industry contains firms in two locations and all firms supply to both locations. The production decision depends on the level of linkages and transportation costs. When transportation costs are high, firms locate close to consumers and thus produce in both locations. When transportation costs are low, firms also produce in both locations, bringing convergence since factor prices are low. For intermediate transportation costs clustering forces come to dominate giving rise to multiple equilibria. Some industries will agglomerate while others may spread out in response to factor price differences.

Krugman and Venables (1996) extend Venables (1996) by studying the process of European integration. This model includes two industries in two countries (regions). Both industries produce final and intermediate goods and use intermediate goods for production. Their technology of production is characterised by increasing monopolistic returns to scale. There is no labour mobility and transportation costs are present. This simple model can be extended to study the dynamics of economic integration between several countries, each containing a variety of industries. The model starts with high transportation costs. Countries in this case will maintain the full range of industries since backward and forward linkages are not strong enough to lead to agglomeration. For very low transportation costs, the country with a strong initial position in some industry finds itself with an advantage that culminates over time due to forward and backward linkages. Each industry will completely concentrate in one country. For the intermediate value of transportation, agglomeration will take place only if industries are initially very unequally distributed.

Puga and Venables (1996) build a model for representing the process of industrialisation. In their model there are N identical countries producing manufacturing (with increasing returns) and agricultural goods (with constant

returns). Trade/transportation costs are present while labour is immobile. The agglomeration forces are input-output linkages between firms in the industrial sector. If these forces are strong enough industry will concentrate in a single country. Wages in this country will be higher than elsewhere but the positive pecuniary externality will compensate for the higher wage costs until a critical mass is reached. At this point it becomes profitable for some industries to move out of this country into another country. More firms eventually move into this country to benefit from the backward and forward linkages, raising wages in this country until a critical mass is reached. The model predicts industrial spillover through a series of waves, from one country to another. Thus only a few countries are industrialised even if countries are identical to each other in their underlying structure.

In **Englemann and Waltz (1995)** there are two regions and four goods: a traditional good produced by skilled and unskilled labour, an industrial commodity, a sector producing non-tradable local goods and services, and a research and development sector. Mobile households supply skilled labour and immobile households supply unskilled labour. Both regions have identical monopolistic production functions. Growth is based on endogenous technological change in the non-traded sector. The model considers two extreme cases. The first assumes knowledge spillovers in research and development which only occur locally. In this case a core-periphery pattern always emerges where the region with a higher initial number of intermediates becomes the only industrial centre. The second extreme case assumes perfect interregional knowledge spillover effects, where knowledge is transported through the mobility of workers and the free tradeability of the industrial good containing the newly developed intermediate goods. This case allows for a variety of possible solutions (depending on the parameter values). These solutions comprise a stable steady state equilibrium with equal growth rates in both regions, even if one region is relatively specialised in the industrial good and the traditional sector is completely concentrated in the other region.

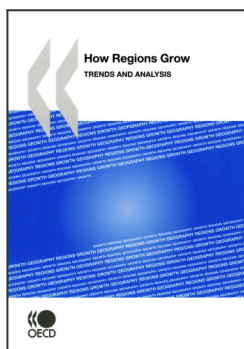
Martin and Ottaviano (2001) merge the NEG with endogenous growth models. Their model includes two regions, each region endowed with a fixed amount of labour assumed to be immobile across regions. Transaction costs are present. A composite good is produced by a homogenous (constant returns) and a differentiated good (monopolistic production technology). The composite good can be used as intermediate input in the innovation sector to create new varieties of the composite good, thus innovation and production are jointly determined. The blueprint of the good is protected infinitely by a patent whose initial property belongs to the region where invention has taken place. The innovation sector is perfectly competitive. Patents can be sold and are initially equally distributed among regions. The equilibria in the model

yield two solutions. If the economy starts in equilibrium there is no incentive to relocate production of the increasing returns sector because the demands for differentiated goods as well as their profits are the same in both regions. If one region gets more firms producing differentiated goods, then the cost of inputs for innovation in that region will be lower due to the presence of transaction cost between the regions. Agglomeration will occur in the region where all the innovation activity has developed. The other region will cease any innovation activity.

Puga (1998a) develops a model similar to Krugman (1991) for exploring why urbanisation patterns in Europe are different than in the less developed countries. The model includes two regions, each allowing for a possible city and agricultural hinterland location. There are transportation costs, labour migration, and two sectors; manufacturing with increasing returns, and agriculture with constant returns. The novelty relative to Krugman (1991) is in allowing for labour mobility between both sectors. With this modification, the elasticity of labour supply is also a pecuniary externality in addition to internal economies of scales in manufacturing and the cost of spatial interactions which encourages firms and workers to choose locations with good market access (which in turn are locations with many firms and workers). Agglomeration is enhanced in the emerging city when labour supply is sufficiently elastic, since labour can be drawn from other cities and from the pool of agricultural workers. Under high transportation costs, the model predicts the emergence of a balanced system of cities. When transportation costs are low, agglomeration forces lead to urban primacy. A high elasticity of labour supply enhances the development of a primate urban pattern. Puga concludes that the larger metropolises present in the less developed countries are due to lower costs of spatial interaction, stronger economies of scale, and more elasticity in supply of labour to the urban centre.

Puga (1999) notes salient differences in patterns of economic geography between Europe and the US. In the latter there are narrower income differentials and a higher concentration of industry. The model in this paper addresses whether integration in Europe will narrow the differences relative to the US, or augment them. The model includes two regions, each with increasing returns in the manufacturing sector and constant returns in the agricultural sector. There are transportation costs, mobility between sectors, and backward and forward firm linkages. The model is divided into two specifications. In the first, labour is also mobile between regions, and in the second it is fixed (but mobile between sectors). The first specification adds forward and backward linkages and intersectoral migration to Krugman's (1991) model. The results obtained in Krugman's model also hold with these additions: high trade costs yield convergence (no agglomeration), and reductions in trade costs beyond a threshold level yield agglomeration. In the

second specification (no interregional migration) firms split between the regions at high trade costs. At intermediate levels of trade they agglomerate due to cost and demand linkages creating wage differentials. At low levels of trade cost firms spread out across regions again since they want to be where immobile factors are cheaper. Thus for the case of European integration (a reduction in trade costs) agglomeration depends on the mobility of labour. If labour is mobile, agglomeration will be intensified. If on the other hand it is not mobile, agglomeration will occur, but eventually firms will spread out across regions in response to the wage differentials.



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