A Dynamic Von Thünen model: agricultural specialisation patterns in Sweden, 1570-1810

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Very Preliminary

This paper presents a dynamic Von Thünen model to analyse the causal link between agricultural surplus and urbanisation. Extensive research suggests that urbanisation emerges as a result of agricultural surplus by allowing for greater specialisation into non-food producing industries (Childe [1935], Wrigley [1985], and Allen [2001], but more recently some studies support causality from the opposite direction (Kopsidis and Wolf [2012] , Martinelli [2014]].

We suggest to explore the dynamic specialisation patterns of parishes close to markets using panel data from population and agricultural productivity from Sweden during the pre-industrial period. We calculate market potential for parishes as a function of increasing population over time, and we distinguish between urban and rural population.

From the mid-16th century onwards the population in Sweden grew 400%, only second to England Schön et al. [2015], although the number of towns also increased, the percentage of people living in towns was less than 10%. With the purpose to re-inforce the urban character of the country, the Swedish Crown compelled towns to hold monopoly rights to trade with its local hinterland, but most of these markets were forced to behave as closed economies. This institutional setting is ideal to test for Von Thünen's rings of specialisation and its dynamism in the context of increasing urbanisation.

Our dataset includes geocoded information on 2,218 Swedish parishes coming from cameral and fiscal records on agricultural surplus in grain measured at 60 year intervals between 1570 and 1810 Palm [2012a,b] and Linde and Palm [2014]). We also use information about the kind of rights held by each town Lilja [1996] and the dates these where in force.

While the model predicts a positive and decreasing relationship between demand and agricultural productivity, where transportation costs are key to local trade, we find that the role of urban market potential to stimulate agricultural productivity was very limited. Our preliminary results show a positive relationship between total market potential and agricultural productivity in rural parishes with an agglomeration shadow effect within 10km from towns, probably explained by the institutional efforts to move population into towns. Consistent with historical records, we find a positive effect of increases in market potential at 10-30km distance in terms of total demand, suggesting that peasants were prone to trade their goods with the markets that were at a day's travel distance.

Using panel data, this paper confirms the limit to specialization patterns of pre-industrial Sweden as claimed by urban development literature Epstein [2001], were the institutional and natural constraints to land productivity force both rural and urban parishes to be engaged with agricultural production.

1 Historical background

Pre-industrial Sweden was a relatively backward country in the European periphery. GDP per capita was among the lowest in Europe, agriculture was generally stagnant and urbanisation rates were low.

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Only Stockholm exceeded more than 5,000 inhabitants whereas the rest of towns were marked by an extremely rural character (Schön et al. [2015]). Yet, there was considerable dynamism in the non-agricultural sectors. For example, production and exports of metals to the Continent sky-rocketed. In the 17th century Swedish bar iron constituted more than 80% of the London market and Swedish copper covered more than two thirds of the European needs. State capacity improved with the centralisation of the state starting with the coronation of King Gustav Vasa (1523). During the 17th century, when continental Europe is often described as stagnant and plagued by the prolonged costs of the Thirty YearsâĂŹ War and subsequent disease, Sweden entered into a dynamic phase of economic growth (Schön and Krantz [2012]) that also resulted in marked territorial expansion with the growth of the Swedish Baltic Empire (1611-1721).

2 The spatial specialisation model

The basic form of Von Thünen's specialisation model suggests a spatial distribution surrounding large population centres or towns. Because this paper is not regarded with the functioning character of early modern Swedish towns, we consider the population of all the parishes in Sweden as the result of organic growth rather than urban growth.[1]

The ability of parishes to specialize depend both on the elasticity of agricultural surplus and institutional factors. Firstly, the possibility to produce crops in different soils across the Swedish land determines whether population can organically grow or not in a particular area. Secondly, the institutional setting that the Crown would define in order to establish a structure or hierarchy between markets and their hinterlands is also a key determinant.

Under autarky, all parishes need to produce food, energy and some industrial goods for their own consumption. In order to survive and keep warm, each parish need to produce at least some minimum subsistence level of agricultural and energy products. If parish A becomes a towns equipped with trading charters, it would be possible to engage in trade and specialization for both places. Parish A would specialise in urban industries and trade, whereas parish B would specialize in producing some kind of agricultural surplus to be transported to the town. Specialization would then be determined by how much surplus that can be generated in parish B after deduction for the transportation costs. How parish B will respond to the induced demand produced by the trading opportunities presented in town/parish A depended on the transportation costs of getting the goods from B to A, shape of the isoquant in parish B, and any level of taxes or customs that might be imposed on the trade.

Transportation costs provide a major limitation to the patterns of specialisation defined by Von ThÃijnen's classic rings that determine how strongly transportation costs could determine land use. The basic idea is that land around the towns specializes according to transportation costs and demand. Products with low transportation costs like cereals can be produced intensively far from population clusters, while products with high transportation costs and less durable (like fruits and greens) need to be produced closer to towns, engaged with trade and other non-agricultural tasks. The model builds strongly on the tyranny of distance. Trade is assumed to take place in the town center only, and given that foods and fuels are necessities to the urban population, there is an indirect limit to the growth of population since their subsistence cost increases rapidly with distance.

In a pre-industrial economy, overland transportation was extremely costly. Bairoch et al. [1988] exemplifies that a man could transport 35-40 kilograms of freight for 30-35 kilometers per day. An oxen-driven chart is often said to be able to transport goods overland for about 70 km in a day. Assuming that farmers wished to return to their home within a day, this leaves the scope for a dayâĂŹs transportation of overland goods to about 30 kilometers (Bergenfeld, 2014 and others).

[1] According to Heckscher [1963] Swedish towns were fairly rural between 1600 and 1800 compared to European standards.

The elasticity of supply of agricultural goods is a key in the model. This variable is best explained in terms of the shape of the isoquant in B and whether this economy will be able to generate any surplus agriculture to be sent to the market depends on the productivity of the agricultural labor force. Although any economy not operating at its frontier capacity could generate increasing agricultural product per acre and levels of crop yields by for example clearing more land, there are clear constrains to population growth. As long as growth of agriculture is extensive in its nature, i.e. generating only population growth and increasing gross production per area the model stipulates limits to specialisation. For a surplus to emerge, intensive growth in terms of increased production per capita is required.

The question whether any limits to an agricultural response was institutional or organic in nature (or perhaps both) has been vivid. Some have stressed that the main impetus for agricultural surplus lay in the institutional arrangements of the local labor markets Grantham [1993], or by institutional factors such as the lack of incentives provided in the feudal society or the common-field system before the enclosure movements.

The latter arguments points to the natural fact that countries different in their organic constraints. A comparative picture of Sweden with respect of other European countries in terms of agricultural production and energy consumption depicts the Swedish economy as remarkably less fortunate than other countries in terms of soil quality and energy needs on average. Although there are some places in Sweden that are as good as the best places in other European countries, the majority of the soil can produce less cereal output than any of the other countries or none at all. Moreover, the energy required in terms of firewood is almost four times as high as in Spain. EnglandâĂŹs remarkably low consumption of firewood is explained by the countries rapid transition into coal as the major source of energy Henriques and Borowiecki [2017]; Kander et al. [2013]. In this sense places with good agricultural endowments might have better chance to grow in terms of their energy capacity production and consumption than those with lower resources. We argue that Sweden was more constrained in terms of energy and could not expand their production and consumption bundle further unless they managed to overcome these constraints through smithian growth (trade).

3 Methodology and data

We suggest to test the extent to provide information on the level at which parishes could specialise by computing the share of agricultural production and livestock in terms of the national share. We then test whether this is a result of Market Potential computed as in Harris (1956) as the sum of population in each parish divided by the bilateral distance. We see the impact of this effect at different distance cut-offs that represent different rings as in Von Thünen.

Our dataset includes geocoded information on 2,218 Swedish parishes that follow consistent historical borders coming from several sources. The main source of information are cameral and fiscal records on agricultural surplus in grain measured at 60 year intervals between 1570 and 1810. These data were put together from church books and tax registers by Linde and Palm [2014], and contain variables on the amounts of seed and harvested grain as well as the available animal stock in each parish. We have combined these agricultural data with a database on the population of historical towns provided by Lilja [1996]. Our dataset includes information about the kind of rights the Kingdom granted to each town and the dates these where in force. **?** Our preliminary results show that the specialisation rings model holds in the Swedish context, but with limits. Parishes that were granted town charters and relieved from the constraints by trade were less engaged with agriculture than the rest of parishes as they would have to deal with trade and some manufacturing. They were, however, more specialized in the production of foodstuffs coming from pigs than the Swedish average.

Agricultural productivity seems increase around 30 km to the town, this is consistent with the literature that suggests that that is exactly the distance one man could travel in a day. However, the

localization of animals such as oxen and cows (that represent a larger capital investment and allow specialization in lower transportation costs production) is motivated by market potential starting 30-70km.

There seems to be no difference between the whole market and the urban market when we control for only the forces determined by the towns charted by the Crown only using urban Market Potential.

Additionally, we find that there is a shadow ring where nothing seems to be produced. This is particularly crucial for parishes between 1,000 and 5,000 inhabitants. We reckon this is showing the energy constraints of organic growth. In order to test for this we look for statistically different coefficients between different sizes of parishes. This test shows evidence that these towns are different in than the rest and their difference manifests in the shadow ring (20-50km).

We find that there is some response of population pressure to agricultural productivity. However, parishes find some difficulties to fully specialize in early modern Sweden. These constrains are not only natural, but also institutional.

Von Thünen's rings of specialization seem to hold to some degree: towns are specialized in non-agricultural products but they have a larger share of pigs within their limits than the average Sweden. Agricultural productivity is positively affected by population pressure, particularly at 20-30km distance from large clusters. Lower transportation costs are located further away. There are, however, energy constraints. Firewood is a crucial necessity for the Swedish economy and it is both a bottleneck and a high transportation cost necessity. Thus, the production of energy is forcefully located in one of the inner rings of the model, closer to the population cluster.

Further analysis to this preliminary research could come from adding data on crucial sectors such as mining (that can be crucial to understand mining towns and the role of oxen) and fishing.

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