Gina Arnesen Eckhoff

Putting Simplicity Back Into New Economic Geography

Master's thesis in Economics
Supervisor: Ragnar Torvik
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Abstract

The field of New Economic Geography analyzes the determinants of the spatial localization of economic activity. Ever since its spark with theoretical models in the 1990s, New Economic Geography has had a development towards more complex frameworks which are better suited for empirical analysis. Accompanying this trend, few analytically solvable New Economic Geography models exist, making it difficult to logically follow the connections between determinants of the spatial localization of economic activity.

This thesis goes back to the roots of New Economic Geography by restricting attention to the early theoretical contributions to the field, which are not analytically solvable. The focus is mainly on Paul Krugman's model from chapter one of his monograph *Geography and Trade*, and why this model cannot be analytically solvable. Furthermore, we put simplicity back into New Economic Geography with an analytically solvable extension to this basic model. A comparison of these models shows that many of the insights about the spatial localization of workers and firms hold in the analytically solvable extension.

Sammendrag

Feltet ny økonomisk geografi analyserer faktorene som påvirker den geografiske lokaliseringen av økonomisk aktivitet. Helt siden feltets startskudd på 90-tallet, har ny økonomisk geografi hatt en utvikling mot mer komplekse rammeverk som er bedre egnet for empirisk analyse. I tråd med denne trenden, eksisterer det få analytisk løsbare modeller innen ny økonomisk geografi, noe som gjør det vanskelig å logisk følge sammenhengene mellom de avgjørende faktorene for lokaliseringen av økonomisk aktivitet.

Denne oppgaven går tilbake til røttene av ny økonomisk geografi ved å begrense fokuset til de tidlige bidragene i feltet, som ikke er analytisk løsbare. Fokuset er hovedsakelig på Paul Krugmans modell fra det første kapitlet i boken *Geography and Trade*, og hvorfor denne ikke kan være analytisk løsbar. Videre gjeninnfører vi enkelhet i ny økonomisk geografi med en analytisk løsbar utvidelse av denne modellen. En sammenlikning av disse modellene viser at mange av innsiktene om den geografiske lokaliseringen av arbeidere og firmaer holder i den analytisk løsbare utvidelsen av modellen.

Acknowledgments

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Contents

1 Introduction

There are many examples of agglomerated regions within countries that form industrial centers. The Chinese town of Wenzhou produces 95 percent of the world output of cigarettes (see Krugman, 2011a, p. 15), and Silicon Valley houses about 30 percent of the world's private-sector high-tech workers (see Faghih, 2019, p. 233). At first sight, these patterns seem to fit well into the concept of comparative advantage stemming from Standard Trade Theory. However, since World War II, most trade has taken place between countries with similar technologies and factor endowments, such as the massive two-way trade in cars between the United States and Canada (see Krugman, 2009, p. 561). This transition has marked a change in the relevance of Standard Trade Theory, which has yet to explain how these industrial clusters emerge over time and how the two-way trade consists of similar rather than dissimilar goods.

Since the 1990s, many economists have attempted to fill this gap by creating models which explain how massive spatial imbalances may arise as a result of the process of increasing economic integration, namely models of New Economic Geography (NEG) (see Gaspar, 2021, p. 46). These are general equilibrium models that explain why industrial clusters emerge and how the production of differentiated goods occurs despite the presence of economies of scale. In addition to explaining patterns of industrial development between interacting regions, these models can be used to answer questions like how the income distribution is affected by the localization of workers and factories and what political measures we can take to raise overall welfare in an integrated economy. We usually consider these models to provide an explanation of the historical industrialization process or the potential for developing nations (e.g. Bjorvatn, 1999), but I argue that they additionally provide valuable insights for today's developed economies.

There are many factors to account for when trying to model the process of economic integration. It is not sufficient to capture the centripetal forces that pull economic activity together, as the centrifugal forces that push it apart are equally relevant. In explaining the inter-regional development patterns which can drive economies to states of either centralization or decentralization, transport costs also become crucial. Furthermore, the presence of transport costs implies that the framework must account for the resources used to transport goods. Incorporating all these factors into an economic model is a complicated task. However, we can achieve it with the help of some simple assumptions in line with New Trade Theory and New Growth Theory (see Fujita & Krugman, 2003, p. 142).

However, developing analytically solvable models is an even more difficult task. Many promising frameworks have described the significant forces at work through different varieties of a general equilibrium model, but the complexity of these models has only increased over time. Except for the contribution by Forslid and Ottaviano (2003), the models are not analytically solvable. This thesis revisits one of Krugman's original NEG models and answers the following question:

Why is Paul Krugman's model from the first chapter of "Geography and Trade" not analytically solvable, and what insights about the spatial localization of workers and firms hold in an analytically solvable extension of the model?

In his monograph *Geography and Trade*, Paul Krugman offers two models which together provided the spark to the field of NEG. We focus on the one from his first chapter, and I argue that he ignores a severe issue by having his alleged solution to the model depend on an endogenous variable. This issue means that the model is not adequately solved and that some of his results have weaker credibility - unless some solvable model can be used to support his conclusions. This thesis provides exactly that by offering an analytically solvable model that captures the same essential features as the early contributions to the field, and that substantiates many of Krugman's findings. We achieve this through making a couple of analytical assumptions which result in a more simplistic framework. Without having the model deviate substantially from previous NEG models, the expressions for the general equilibria of the model are only dependent on exogenous variables.

The thesis proceeds as follows: Chapter 2 provides a background on the field of NEG, starting with a broad overview of the field, followed by a deeper focus on the literature that has been the basis for developing the extended model in this thesis. Chapter 3 presents the basic model presented by Krugman in the first chapter of his monograph

Geography and Trade and some key takeaways from it. Chapter 4 presents the extended model. Through a comparison of the two models, chapter 5 discusses why Krugman's original model cannot be analytically solvable and how the analytically solvable model substantiates some of his original findings. It also poses questions for future research. Finally, chapter 6 concludes.

2 Background

Before diving into the models we compare in this thesis, this chapter provides some general background on NEG models as a point of departure. The first subchapter provides a broad overview of the field of NEG. The second subchapter looks at some common properties of NEG models. Then follows a deeper dive into the Dixit-Stiglitz framework, an important contribution for simplistically modeling increasing returns. After this follows an overview of how we can model forces that affect the localization of economic activity. We cover transport costs separately because they have an ambiguous effect on localization. Towards the end of the chapter, we look at the so-called "Big Push" mechanism, which is relevant to the extensions of the literature in chapter 4. Finally, we summarize with some key takeaways from the background on NEG models.

2.1 Overview

The monograph *Geography and Trade* (Krugman, 1991a) is usually considered the beginning of NEG (see Krugman, 2011b, p. 1). However, the discussion of his contribution usually restricts attention to the Core-Periphery model he presents in the Appendix, which is rather similar to the model he published in the Journal of Political Economy the same year (Krugman, 1991b). Although the Core-Periphery model does deserve the attention it has received, there are also many useful insights to draw from the basic model in the very first chapter of the book. Stepping back from the recent developments in NEG, this thesis picks up on the early contributions, with a particular focus on the fundamental model provided by Krugman. In order to contextualize why we revisit these roots, we first need a general overview of the development of the field.

The original Core-Periphery framework has been extended in several dimensions, contributing to deeper insights into new aspects of spatial economic imbalances. One area of development looks at the internal structure of regions and city formation, e.g., endogenous patterns to agricultural and urban land use (Fujita & Krugman, 1995). Other researchers have identified alternative ways to implement the forces that pull economic activity together and those that push it apart. Examples of these are an alternative pulling force introduced through modeling a congestible, non-tradeable resource (e.g. Helpman, 1995; Krugman & Elizondo, 1996), and an alternative pushing force, captured through input-output linkages in production (e.g. Krugman & Venables, 1995; Venables, 1993). The role of regional growth is also examined, for instance, through a model with mobility of capital (Baldwin & Martin, 2004), and through a model that incorporates endogenous growth and horizontal innovation (Fujita & Thisse, 2003). The role of multiple sectors is also investigated, for instance, by adding a non-tradable goods sector (Pflüger & Südekum, 2008). Incorporating heterogeneity is another insightful contribution, and it is both considered at the level of consumers and firms (e.g. Ottaviano, 2010), and at the level of the migration choice (Mossay, 2013; Redding, 2016; Tabuchi & Thisse, 2002).

Furthermore, the field has inspired a new area of economics that is even more applicable to the empirical analysis of spatial economics, namely Quantitative Spatial Economics (QSE) (see Redding & Rossi-Hansberg, 2017, p. 2). These are quantitative models of economic geography which simultaneously incorporate several forces which pull economic activity together and several forces which push it apart. They also connect to the empirical data through heterogeneous locations and gravity equation relationships for trade and commuting (see Gaspar, 2021, p. 47).

The general trend is thus that NEG has become more complex and better suited for empirical analysis, perhaps partially as a reaction to the many critiques by geographers (see Gaspar, 2021, p. 61-74). Although many insights arise from these developments, most models share the same shortcoming; they are not analytically solvable. This deficiency results in a problem of tractability[1], because it becomes difficult to identify the effects which are at work and how they affect the equilibria of the model. In order to develop a more tractable model this thesis looks to the simplest model of them all as a point of departure, namely the one accounted for in chapter one of Krugman's monograph. Additionally, some other papers have inspired the process of developing the more tractable model. We look at these papers in the rest of this chapter (the papers are also listed in Table 2 in Appendix B).

[1] *Tractability*; A description of a model which is easy to analyze. Maximum tractability implies that we can solve the model with analytic methods, like pen and paper calculations (see Gabaix et al., 2008, p. 6).

2.2 Shared Properties of New Economic Geography Models

Though many varieties of the NEG framework exist, some common traits to the basic theoretical models usually persist. These are the assumptions of two regions, two production sectors, and two types of labor. The two sectors are respectively agricultural and industrial, and their only input is labor. The two types of labor correspond to respective sectors, namely farmers in agriculture and workers in the manufacturing industry. Agriculture provides a homogeneous good with constant returns to scale (CRS). Industrial firms produce a continuum of differentiated goods[2] with either CRS or increasing returns to scale (IRS). The industrial goods are substitutes for each other, but not for the agricultural goods. Farmers are immobile and equally distributed between the two regions. Modern workers can be employed in any region but need to live where they work. Firms must offer all goods in both regions. There are no transport costs for agricultural goods, but modern goods face a transport cost carried by the producers when they ship them between regions.

In order to discuss the processes that are at work in the models, it is necessary to understand how the analytical specifications work and what their limitations are. Given the similarities of many of the models, it is interesting to focus on the cases where they differ and what implications these differences have for the dynamics of the models. In some cases, the alternative modeling strategies yield the same results as before, strengthening the validity of previous contributions. In other cases, the alternative strategies yield entirely new results, which raises questions for future research.

The rest of this chapter is devoted to a brief discussion of some main contributions to the field. We look at how different implementation strategies seem to affect the economic processes in the models and leave some open questions which are yet to be answered. The first contribution we look at is the monopolistic competition framework introduced by Dixit and Stiglitz (1977).

[2]Defining a continuum of differentiated goods is an assumption made for analytical simplicity, which allows for there to be any number of goods, but economizes in notation by indexing these in the interval [0,1].

2.3 The Dixit-Stiglitz Framework

One important explanation for the emergence of industrial clusters is economies of scale because these make it more beneficial to gather production in one place. However, without an analytical framework representing increasing returns at the firm level, it is impossible to capture this essential effect. Despite perfect competition being a highly unrealistic representation of the forces at work in an economy, the field of economics has for long been dominated by models with CRS and perfect competition. This shortcoming stems from the long-withstanding computational issues associated with imperfect competition. Fortunately, the picture changed with the publishing of the Dixit-Stiglitz framework of monopolistic competition, which we can use to model increasing returns at the firm level without making the models too complex.

There are two key characteristics to the Dixit-Stiglitz framework, namely a factor function with IRS and a utility function implying that consumers have a so-called "love of variety."

$$L = \alpha + \beta x \tag{1}$$

Equation (1) is an example of a factor function with IRS properties, where the necessary labor input L in order to produce x goods consists of a fixed cost α and a marginal cost $\beta < 1$.

$$u = \left[\sum c^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{2}$$

Equation (2) is an example of a utility function that captures the love of variety, where u is the utility of each identical consumer, c is consumption, and σ is the elasticity of substitution between the goods.

In NEG models, the Dixit-Stiglitz framework allows for incorporating IRS in the modern sector while assuming that the products are good substitutes and that consumers have a love of variety. The love of variety results from the utility function, characterized by lower marginal utility when the consumption of one good increases. Consequently, utility is higher when the population consumes a greater variety of goods. Thus, despite the IRS technology, there is an element of competition between firms within the same industry. More firms will establish to produce new varieties of the good, and when more firms establish, existing firms' profits and market power will decline. We have seen that monopolistic competition becomes almost as simple to model as perfect competition.

In addition to the obvious computational advantages of this framework, another advantage is that it is more relevant for how economies interact today. Trade after World War II has been increasingly characterized by the exchange of similar products such that consumers can choose among more varieties (see Krugman, 2009, p. 561), and this corresponds well with the features of monopolistic competition. Paul Krugman used the framework to create a model examining the pattern of trade, suggesting that regions tend to export the goods for which they have large regional markets (Krugman, 1980). However, many questions were left unanswered with this model, and the path-breaking insights did not arrive until he used the framework to create the Core-Periphery model (Krugman, 1991a, 1991b), which contributed to the spark of NEG.

2.4 Agglomeration and Dispersion Forces

As pointed out by Fujita and Krugman (2003), NEG models need to simultaneously capture the forces that pull economic activity together and the forces that push it apart (p. 3). Only then can we describe how the tension between these forces shapes the geographical structure of an economy. *Agglomeration forces* affect economic activity[3] to locate where there is already more economic activity, and *dispersion forces* affect it to locate where there is already less economic activity. See Figure 1 for an illustration of agglomeration and dispersion forces.

[3]Where "economic activity" refers to the economic agents; workers and firms.

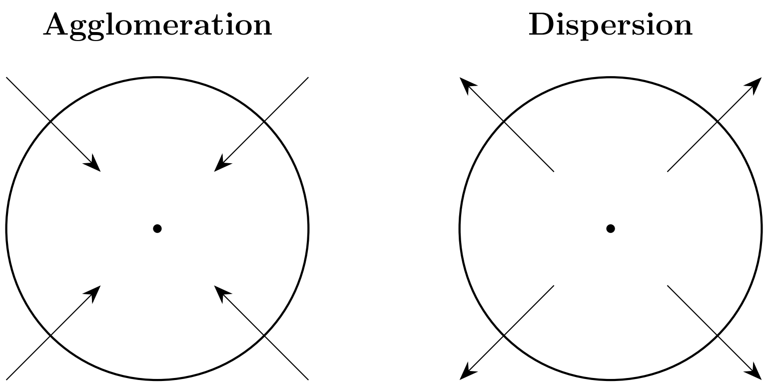

Figure 1: Agglomeration and Dispersion Forces

Agglomeration forces drive economic activity towards centers, while dispersion forces drive economic activity away from centers.

It is necessary to capture at least one agglomeration force and one dispersion force. We can implement these forces in several ways, and each implementation strategy sheds light on different aspects of the localization of economic activity. Below follows a brief introduction to the main strategies and what insights they provide for NEG.

2.4.1 Agglomeration Forces

There are two common strategies for how to implement agglomeration forces in the most simple NEG models.[4] The first strategy focuses on the share of the workforce in a region as a source of a *home market demand*, and the second focuses on *input-output linkages* in industries.

Home Market Demand

Suppose we assume full employment and full factor mobility between regions. In that case, modern workers move wherever they can find a job.[5] This mobility results in a demand externality which contributes to agglomeration, commonly implemented in the

[4]If we instead look to quantitative spatial models, alternative sources of agglomeration in economies of scale can be shown, for instance, endogenous components of productivity and amenities (see Redding, 2020, p. 14).

[5]Note that there is some dispute about this claim, as some researchers assume that modern workers need to be offered a wage premium in order to be flexible about their region of residence. See for instance Bjorvatn (1999).

first NEG models (e.g. Krugman, 1991b).

Consider a hypothetical situation of full decentralization, where both regions produce modern goods. In this case, the population is equally divided between the regions. Now assume that one firm decides to move its production in one region to take better advantage of the IRS. Workers from the closed factory will move to the region where production has increased, making the population size in this region increase. When other firms then consider the profitability of where to localize, they will take into account that the local market is now bigger in this region. If this makes the other firms gather production here as well, the population size in the region will continue to grow, further increasing regional demand. This demand externality stemming from the local population is the *home market effect*, and it makes industrial agglomeration more likely. We have seen that we can model the home market effect by assuming IRS and the mobility of workers.

Input-Output Linkages

Modeling an agglomeration force by assuming the mobility of modern workers is not the only possible approach. Another factor that can contribute to the emergence of industrial clusters is the *input-output linkages* between firms. This is illustrated by Krugman and Venables (1995), using the framework of Venables (1993). With the assumption that labor is immobile, they provide a model where two nations trade final products but not factors of production.[6] Even without labor mobility, they show that industrial agglomeration is possible by capturing the importance of closeness to markets and suppliers. They achieve this by subdividing the modern sector into two industries, an "upstream" (primary) industry that produces intermediate goods and a "downstream" (secondary) industry that uses the intermediates to produce final goods.

If one region is larger than the other, we have a *backward linkage* and a *forward linkage.* The backward linkage is that the upstream industry wants to locate in the larger region because its market is the biggest. The forward linkage is that the downstream industry wants to locate where there is more production of downstream goods. Rather than firms

[6] Naturally, input-output linkages are equally relevant for cases that are not on the national level, but the contribution from these authors was to show that industrial agglomeration is possible even without factor mobility.

localizing where the population size is the largest, they now localize where they can access cheaper inputs and a greater source of demand. Thus, we have seen that these input-output linkages provide a source of agglomeration which does not rely on the mobility of workers.

2.4.2 Dispersion Forces

So far, we have seen two ways to implement agglomeration forces, and we will now look at two ways to implement dispersion forces. Even when there is full concentration of the modern industry in one region, a force pulling economic activity away from this center still exists. The two implementation strategies for the dispersion forces that capture this have in common that they identify some immobile factor in each region. One way to model dispersion forces is to incorporate an *immobile demand* (e.g. Krugman, 1991b) and the other is to incorporate an *immobile supply* (e.g. Helpman, 1995; Krugman & Elizondo, 1996).

Immobile Demand

The first way to implement a dispersion force is through an immobile source of demand. The strategy is based on the assumption that some share of the population always resides in each region. Thus, even if we have a concentration of all modern firms in one region (the *core*), some farmers still have to work in the other region (the *periphery*). Although these farmers might represent a tiny fraction of the population, they still demand modern goods which firms have to transport to them, and the firms need to cover the costs of this shipping. All other things being equal, a firm can then reduce costs by establishing production in the periphery since this involves not having to cover transport costs anymore. The existence of this opportunity is a source of dispersion, pulling the economy towards economic decentralization.

Immobile Supply

The second way to implement a dispersion force is through an immobile supply source. Taking Helpman (1995) as an example, he introduces an additional consumption good that we cannot ship between regions. This good is congestible, such that when the population size in a region increases, the good becomes more expensive and provides lower individual utility. An example of such a good can be housing, which tends to become more expensive in populated areas. Another example is the access to natural amenities, of which the utility of consumption declines with crowding. Simulations based on Helpman's model predict that the probability of decentralization increases with lower transport costs. This prediction is precisely the opposite result of what Krugman achieves.

Transport costs also create a significant force affecting where economic agents want to localize. However, there is great uncertainty regarding how transport costs affect localization. Therefore, we look at these separately in the following subchapter.

2.5 Transport Costs

So far, we have considered several forces which affect where firms choose to locate. However, we have not yet looked at transport costs, one of the most interesting factors. The reason for withholding this discussion until now is twofold. Firstly, economic geographers still debate whether transport costs contribute to pulling economic activity apart or to pushing it together. Secondly, as future transport costs per good are prone to shift, partialling out their effect on spatial economic outcomes is crucial for understanding future economic prospects. Though we expect a reduction in transport costs due to technological improvements and better infrastructure, political trade barriers might distort the actual costs. Globalization was initially associated with reduced trade barriers causing decreased trade costs, but waves of increased protectionism have characterized recent years, causing trade costs to increase again (see Gregori, 2021, p. 1-13).[7]

In NEG models, we usually model transport costs as "iceberg" (ad valorem) costs, following Paul Samuelson's notion from 1954 (Samuelson, 1954). When a good is shipped, we assume that a certain percentage of this good disappears during shipping so that more

[7]Note that political concerns about trade costs are most relevant in cases where the trading regions represent different nations. The most common assumption in NEG models is that trading regions belong to the same country, but some models incorporate trade between nations (e.g. Krugman & Venables, 1995).

than one unit needs to be sent for one unit to arrive. The most common assumption is that modern goods are the only ones facing a transport cost and that this cost only occurs when shipping the modern goods across regions. The cost per transported unit and the total demand from the remote region determine the size of the total transport costs.

We have identified a shortage of tractable models that use comparative statics to predict the relationship between transport costs and the localization of economic activity. Even though NEG models usually incorporate transport costs of the same "iceberg" manner, there are significant discrepancies in what the models imply to be the effect of transport costs. To take Krugman (1991b) and Helpman (1995) as examples, Krugman finds that transport costs seem to contribute to less concentration of industry, while Helpman finds that they contribute to more concentration of industry. Since they model the transport costs the same way, the discrepancies in their predicted effect on localization seem to stem from other traits in the models. However, since these models are not analytically solvable, investigating why they get different results is a difficult task. Nonetheless, considering the uncertainties about future trade costs, this seems like a critical research gap to close.

2.6 The Big Push Mechanism

Before summarizing, we consider a mechanism that can occur when multiple equilibria of economic localization are simultaneously possible. It is called a *Big Push mechanism*, and it is formally introduced in a model of industrialization by Murphy et al. (1989). In NEG models, we have seen that it can be possible that economic activity is decentralized (dispersed evenly between regions) and that it is centralized (one industrial core and one remote periphery). A question yet to be asked is what happens if both of these equilibria are possible simultaneously. Suppose one equilibrium yields higher utility than the other. In that case, there is room to raise overall welfare by inducing a transition from the sub-optimal equilibrium (*poverty trap*) to the optimal one, and we refer to such an action as a Big Push.

We briefly look at the main aspects of the original model by Murphy et al. (1989) in order to illustrate the idea behind the Big Push mechanism. Their model does not consider multiple regions, but it uses a monopolistic competition framework to represent imperfect competition, assuming a fixed number of firms. The firms produce differentiated goods and can choose between CRS or IRS technology. With CRS as a starting point, the firms can *industrialize* by inducing a fixed cost in order to produce with IRS. Therefore, an equilibrium where all firms have industrialized (and where total income is higher) may exist.

Though this equilibrium may exist, the individual firm does not necessarily face a profit from industrializing if no other firms follow. For industrialization to be profitable on the firm level, a certain number of firms must already have industrialized. Even though there is a positive demand spillover when a firm produces with IRS technology, workers divide this demand between the consumption of all goods, and it does not compensate for the individual firm's cost of industrializing. This lack of individual compensation is a coordination problem. Unless the firms get a Big Push, that is, get compensated or ensured that a sufficient number of firms will follow their path, they will choose to remain in the sub-optimal equilibrium.

It is possible to incorporate the insights provided by the Big Push framework into NEG models. For instance, Bjorvatn (1999) explicitly incorporates a Big Push mechanism in a NEG model where he assumes that there are two firms which produce two goods with either CRS or IRS technology. He ensures the existence of a profit income in the same way as Murphy et al. (1989); by assuming that there is a given number of firms. Instead of allowing more firms to compete until they drive profits down to zero, the firms now have an opportunity to gain a profit income by improving efficiency. Bjorvatn assumes that some of this profit goes to the workers in the modern sector as a wage premium and that modern workers move to the sector which offers the highest wage. Therefore, he argues that it is sufficient to look at the firm owner's decisions to determine where both the firms and the workers will localize. His contribution illustrates that incorporating the Big Push mechanism into NEG models can be used to show how there is room to raise welfare in economies that are stuck in poverty traps. Furthermore, it illustrates that we can implement this without drastic changes to the basic framework.

Though Bjorvatn makes the assumption of a wage premium, empirical evidence suggests that wage premiums are not always present in cases of industrial agglomeration. Using data on Italian households, De Blasio and Di Addario (2005) find that working in an industrial cluster does not provide a wage premium but that it improves the job market opportunities for the workers. However, to my knowledge, there exists no NEG model which incorporates a Big Push mechanism without the assumption of a wage premium.

2.7 Summary

In 1991, Paul Krugman publishes the revolutionary Core-Periphery Model in his monograph *Geography and Trade*, which sparks the creation of NEG (Krugman, 2011b). Using Dixit-Stiglitz monopolistic competition, he illustrates how inequalities in economic activity can emerge as the general equilibrium even when regions are assumed to be symmetric (Krugman, 1991a). It does not take long before other economists catch the wave and publish similar models, exploring different methods to capture the same general tendencies (see Gaspar, 2021, p. 46-49). Although their contributions make highly influential predictions regarding the role of main parameters through simulations, few of the models are analytically solvable. Thus, we can question the generality of the results, as they depend on which parameter values we use as inputs in the simulations. Furthermore, an explanation for the contradictory prediction on the effect of transport costs is still lacking, even though transport costs are a crucial determinant for economic outcomes.

In this chapter, we have looked at some key traits of the most basic NEG models - sources of agglomeration and dispersion of economic activity, the role of transport costs, and the potential for a Big Push mechanism. This overview provides an intuitive introduction to some of the essential mechanisms in these models. In the next chapter, we take a deeper dive into the most basic NEG model, which is the one presented informally by Paul Krugman in the first chapter of *Geography and Trade*.

3 The Basic Model

In chapter 1 of his monograph *Geography and Trade*, Paul Krugman provides a recipe for a simple model of geographic concentration and sketches an example of such a model (see Krugman, 1991a, p. 1-34). Accounting for increasing returns, transportation costs, and demand, he shows how sufficiently strong economies of scale can make firms serve the national market from production at a single location. Though his recipe is ground-breaking in many ways, the model he sketches according to this recipe faces the fundamental shortcoming of not being analytically solvable. This chapter is devoted to presenting his model of geographic concentration, and we will use it as a reference point in the discussion of why the model does not provide an analytical solution.

3.1 The Model of Geographic Concentration

There are two regions, East (E) and West (W), and two industries, Agricultural (A) and Modern (M). Both industries only use labor as their input factor, but there are different types of labor - immobile farmers in Agricultural and mobile workers in Modern. The farmers are a share $(1-\pi)$ of the population, and the modern workers are a share π of the population. Agricultural production is equally divided between the two regions. The population size is normalized to one, which implies that there will always be $\frac{1-\pi}{2}$ farmers in each region and π modern workers who can reside in any region. Agricultural production is characterized by CRS technology. Modern production has IRS technology due to a marginal productivity of less than one and a fixed cost F associated with opening each modern factory. The localization of the population (represented by the PP curve) and the localization of the manufacturing firms (represented by the MM curve) change endogenously until the economy reaches a steady state.

3.1.1 The PP Curve: Localization of the Population

The PP curve illustrates how the share of the population in West (S_N) depends on the share of manufacturing in West (S_M). The population consists of both farmers and modern workers. The localization of farmers is exogenous, whereas the localization of modern workers is dependent on where there is modern industry. Assuming full employment and that modern workers have to reside in the region they work in, the modern workers are subject to the firms' decisions about localization and will thus move wherever they can find modern employment.[8] The PP curve is given by equation (PP).

$$S_N = \frac{1-\pi}{2} + \pi S_M \tag{PP}$$

Although interpreted as the population size in West, it should be noted that S_N is measured as a share of the total population, which has been normalized to one. Half of the farmers reside in West, so the population size is at minimum equal to half of the agricultural population, $\frac{1-\pi}{2}$. This is captured by the first term in equation (PP). The second term captures that the more manufacturing in West ($S_M \uparrow$), the more additional workers will reside in West. This gives the linear curve a slope of π. The population size in West is at its maximum of $\frac{1+\pi}{2}$ when all industry is concentrated there, such that $S_M = 1$. Equation (PP) gives the PP curve which is illustrated in Figure 2.

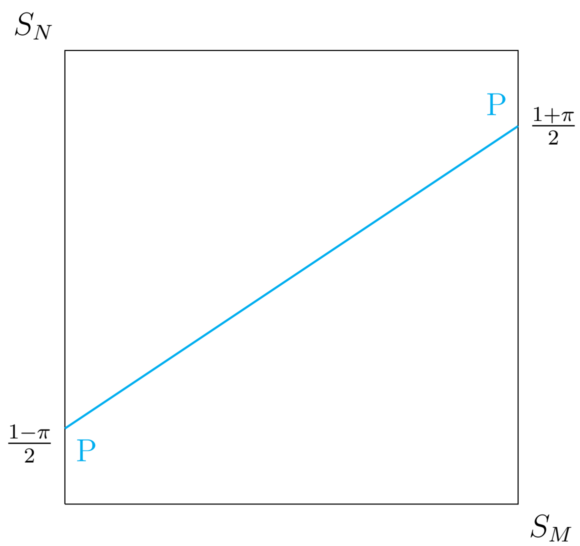

Figure 2: The PP curve

The share of population in West (S_N) increases with the share of manufacturing in West (S_M).

[8]There are many theories supporting that workers and firms localize in the same regions, even without the assumption of full employment. See for instance *Labor Market Pooling* (Marshall, 1920).

3.1.2 The MM Curve: Localization of Manufacturing Firms

The MM curve illustrates how the share of manufacturing firms in West (S_M) depends on the share of the population in West (S_N). This is not a linear curve, as there are kinks at critical thresholds. The critical thresholds define when it is profitable to concentrate production in one region and when it is profitable to split production evenly between two regions, and they can be stated as follows:

$$S_M = \begin{cases} 0 & \text{if } S_N < \frac{F}{tx} \\ S_N & \text{if } \frac{F}{tx} < S_N < 1 - \frac{F}{tx} \\ 1 & \text{if } 1 - \frac{F}{tx} < S_N \end{cases} \tag{MM}$$

The interested reader can find an analytical explanation for these conditions in Appendix A.1, but we restrict to the simple intuition here. Each firm faces the choice between producing its goods from one location or producing them from both locations, and it will make its choice between these two alternatives based on what yields the highest profits.

On the one hand, there is a cost associated with opening an additional factory, which is given by F. On the other hand, there is a cost associated with having all production in one place, which is equal to the cost of transporting goods from one region to another. This is composed of a unit transport cost t and demand from the other region, given by either $S_N x$ or $(1 - S_N)x$ depending on which region is the center. The total sales from each firm is given by x, and this is multiplied by the share of the population residing in the remote region. If the center is in East, the population in the remote region is given by S_N. If the center is in West, the share of the population in the remote region is given by $(1 - S_N)$.

A modern firm can either avoid transport costs by serving the market from both locations or choose to pay these if it finds it more beneficial to take advantage of the economies of scale by centralizing all production in one region. The result of these considerations is the MM curve, which is illustrated in Figure 3.

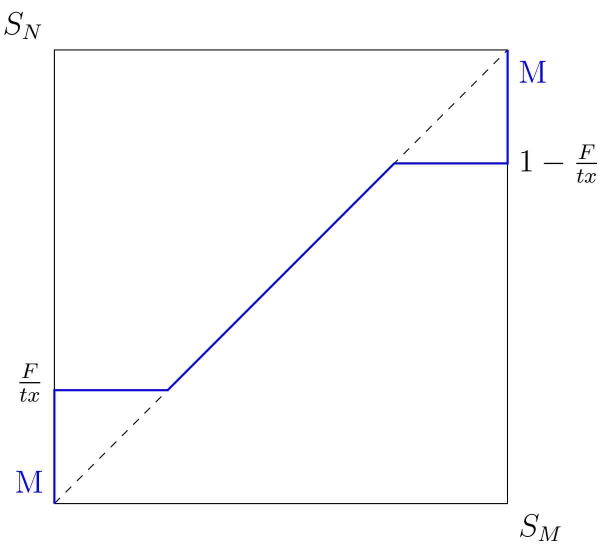

Figure 3: The MM curve

The share of manufacturing in West (S_M) increases with the share of population i West (S_N), as long as the share of population in West has surpassed a critical threshold of $\frac{F}{tx}$.

3.1.3 Equilibrium Localization

In order to explain the equilibrium localization of workers and firms, the PP and MM curves are illustrated together in Figure 4.

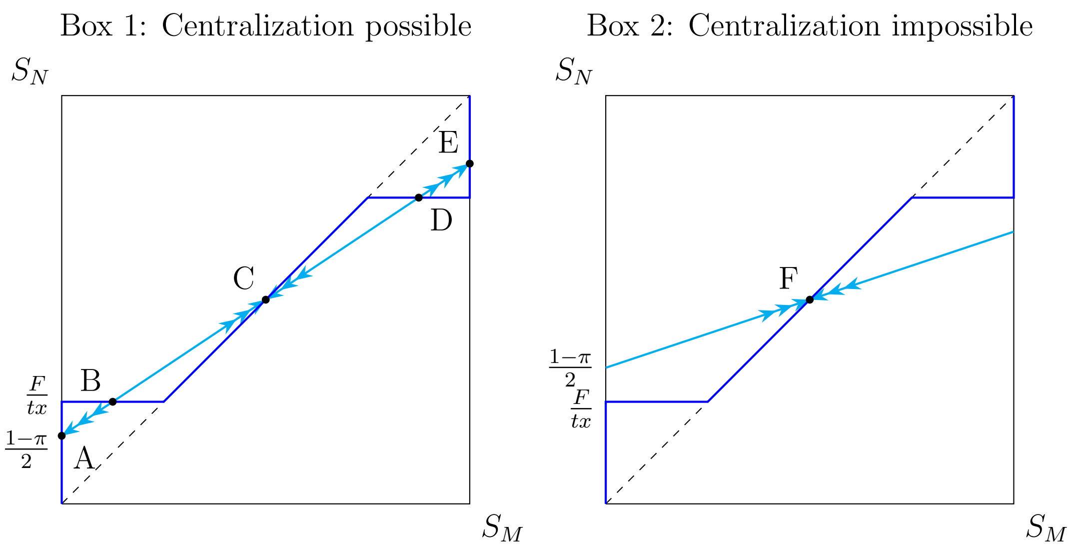

Figure 4: Equilibrium Localization

The PP and MM curve together. In Box 1 centralization is possible, and in Box 2 it is impossible.

Assuming that workers move faster than firms, an interpretation of Figure 4 is that when the PP curve lies below the MM curve, the share of the population in West (S_N) will decline through a movement along the PP curve. Likewise, when the PP curve lies above the MM curve, the share of the population in West (S_N) will increase through a movement along the PP curve. The arrows in Figure 4 represent these movements, and they illustrate the stability properties of the different equilibria.

The equilibria in the model are points where the PP curve meets the MM curve, and they are stable if the arrows indicate movement towards them. They are unstable if the arrows indicate movement away from them, which means that if a marginal shock in one of the parameters occurs while the economy is in such a point, this will force a movement where the endogenous variables S_N and S_M are driven further away from their initial states.

There are two boxes in Figure 4, illustrating that it may or may not be possible with full industrial concentration. In Box 1, there are five equilibria, but only three of these are stable (A, C, E). Point A and E represent *full centralization*[9] of manufacturing in either region, and point C represents *full decentralization*[10] of manufacturing. In Box 2, there is only one equilibrium, F, which is stable and characterized by full decentralization.

The difference between the situation in Box 1 and Box 2 is essentially where the curves intersect at the vertical axis. This difference illustrates that the following conditions decide whether centralization is a possible equilibrium:

$$\frac{F}{tx} > \frac{1-\pi}{2} \quad \Longrightarrow \text{Centralization is possible}$$
$$\frac{F}{tx} < \frac{1-\pi}{2} \quad \Longrightarrow \text{Centralization is impossible}$$

[9] *Full centralization*; all modern firms (and thereby all modern workers) are located in one region.

[10] *Full decentralization*; the modern firms (and thereby all modern workers) are evenly distributed between the two regions.

We rewrite the first expression in order to define what level of transport cost per good makes centralization possible:

$$t < \frac{2F}{x(1-\pi)} \qquad (*)$$

Condition $(*)$ shows that according to Krugman's model, there is more industrial concentration in cases where the share of the population employed in agriculture is sufficiently low, when the benefits of scale ($\frac{F}{x}$) are sufficiently high, and when the transport costs (t) are sufficiently low.

3.2 Takeaways from the Model of Geographic Concentration

A central motivation for using this simple model as a point of departure is the way Krugman incorporates the firm's decision-making. He proposes a way of thinking about firms where they, rather than choosing which location to establish in, choose between producing from one or more locations based on a consideration of profitability. This way of thinking about modern firms is important to notice as we depart from it from in future NEG models which instead follow the example posed in his Core-Periphery model (Krugman, 1991b). In these later models, firms cannot split or merge; they can simply choose between locating in one region or the other. Thus, centralization is the outcome of all firms choosing the same location rather than all firms choosing to produce from one single plant. By looking at the firm's decision in the same way as Krugman did in this model, it becomes easier to consider the individual profitability of the choices the firm faces,[11] which again makes it easier to construct an analytically solvable model.

As Krugman himself points out, the model is sloppy in many of its features. He claims that there are benefits to scale but never specifies any market structure in the model. Without any market structure being specified, it is also impossible to tell whether there will be any profit income for the firms or if they will compete by establishing more firms

[11] Rather than formulating functions that can be used to compare the profitability of the localization of a factory, the problem can be restricted to finding benefits and losses associated with gathering or splitting production.

until they drive profits to zero. This again makes it impossible to discuss whether total income differs between the possible equilibria of the model. Krugman himself raises many of these issues, and he justifies his simple model by claiming that it is merely one of the many examples of how to use the recipe he proposes for building NEG models.

When comparing this model with the one presented in the next chapter, I make the argument that there is one substantial shortcoming in Krugman's model of geographic concentration which he has not addressed. He treats condition $(*)$ as a solution to his general equilibrium model, but I argue that this cannot be the case. Thresholds defining the stability of equilibria in a general equilibrium model should only contain exogenous variables, but I argue that condition $(*)$ contains an endogenous variable.

After presenting an extension of his model where technology, utility, transport costs and income are explicitly specified by functions, it will become clear that x, the total sales from each firm, cannot be exogenous. Sales should rather depend on technology and the choice between producing from one or two locations. Thus, he has not provided sufficient theoretical evidence for his conclusion that "the concentration of production is arbitrary, and can be presumed to be a function of initial conditions or historical accident." The remaining question is whether his claim holds if the model is fully specified, that is, whether it is possible to find general equilibria that only rely on exogenous parameters with an extended model.

4 The Extended Model

Now the time has come to present the model I have developed as an alternative to the one we reviewed in the previous chapter. As opposed to the basic model, this extended version explicitly specifies functions for technology, utility, transport costs, and income. It is a general equilibrium model which can be used to explain how countries end up in states of centralization, and decentralization, of economic activity. This has already been done in many other NEG models. However, there is one unique quality of this model - it offers general equilibria that only depend on exogenous variables. Given that the model's assumptions are accepted, it thus provides clear results on how all the relevant parameters affect the centralization and decentralization of economic activity.

The next subchapter formally sets up the model. Thereafter, we find the solutions for the general equilibria. Then we use the model to discuss implications for the localization of economic activity. After that, a welfare discussion follows, and finally, a summary with some key takeaways from the model.

4.1 The Model of Centralization or Decentralization

There are still two regions and two industries, Agricultural and Modern. Agricultural goods are still produced with CRS, but modern goods can now either be produced with CRS or IRS. There are no transport costs for agricultural goods, but there are transport costs for modern goods when they are shipped between regions. Firms carry the transport costs, and (in equilibrium) all goods are offered in both regions. It is assumed that all inhabitants are workers, and the number of workers is normalized to one. A share $(1-\mu)$ is employed in Agriculture, and these farmers are immobile between regions. The remaining share μ is employed in Modern, and these modern workers are mobile between regions. The number of modern firms equals the number of varieties of modern goods, n. Among the modern workers in each firm, some (but not all) are shareholders. All modern workers receive a wage income equal to one, but the shareholders additionally receive a share of the firm's profit income. If there is only one shareholder per firm he/she receives all the firm's profit income, and when there are more shareholders they split the profit income.

4.1.1 Utility

$$U_i = C_{Mi} \qquad \text{where } C_{Mi} = C_1^{\frac{1}{n}} C_2^{\frac{1}{n}} ... C_n^{\frac{1}{n}} \tag{3}$$

All individuals share the utility function specified by equation (3), where U_i denotes individual utility and C_{Mi} is an aggregate of the n modern goods. Consumption of agricultural goods implicitly yields zero utility but is a subsistence need that is constant with respect to income. Thus, consumers direct all excess income towards modern goods after covering the subsistence needs, and this consumption is what yields positive utility.[12] Consequently, when an economy faces an increase in income, this extra income will only be directed toward the consumption of modern goods. The utility is highest when the consumer divides income equally between the n modern goods.

4.1.2 Workers and Production

A share $(1 - \mu)$ of the workforce is employed in agriculture. The remaining share μ is employed in modern production. The land used in agricultural production is immobile and equally divided between the two regions, such that a share of $\frac{1-\mu}{2}$ farmers are always employed in each region. These farmers represent an immobile source of demand for goods. Since there is CRS technology and perfect competition in agriculture, agricultural goods are sold at a price of 1, and the farmers have a salary of 1.

Modern workers are either employed in production with CRS or IRS technology. They are mobile to work and reside in any region, but they must live in the region where they work. There are n types of firms responsible for producing n different goods, regardless of the choice of technology. Firms with CRS technology use one input of labor to produce one unit of a good, and thus sets prices and wages equal to one. Firms with IRS technology face competition from the CRS firms, which means that prices and wages will be equal to one regardless of the choice of technology.[13]

[12]Note that this specification is not a limitation but a way to economize on notation, which can be interpreted as a normalization of agricultural consumption (which is constant) to zero.

[13]Note that some workers will have an income higher than one because they in addition to the salary of one receive a profit income.

IRS production uses labor input according to the following factor function:

$$L_{Mi} = \alpha + \beta x_{Mi} \tag{4}$$

Equation (4) is the same factor function as the one Krugman used in his renowned Core-Periphery model. For each firm i, this factor function expresses how many modern labor inputs (L_{Mi}) are needed in order to produce x_{Mi} goods. The fixed costs α are measured in terms of labor units, and we assume that $\alpha > 0$. The necessary labor for producing each additional unit of the modern good is given by β, and in order for IRS production to be possible in equilibrium, we assume that $0 < \beta < 1$.

4.1.3 Transport Costs

There are no transport costs on agricultural goods, but modern firms that ship goods across regions cover a transport cost such that they can offer a price of one in all regions. The transport cost is of the "iceberg" type, such that when one unit of a good is shipped, a share τ arrives, implying that a share $(1 - \tau)$ has been lost during shipping. This gives a transport cost per unit shipped of $\frac{1-\tau}{\tau}$ (see Appendix B.1 for an explanation).

There are a couple of details we should notice about the transport costs per unit shipped. Firstly, that an *increase* in τ implies *lower* transport costs $\frac{1-\tau}{\tau}$. Secondly, that it cannot be profitable for goods produced with CRS technology to be shipped at all because the total costs (production costs plus transport costs) would be higher than the total revenue. And finally, that shipping modern goods produced with increasing returns is only profitable on the margin when the transport costs are lower than the markup ($\frac{1-\tau}{\tau} < \frac{1}{\beta}$). To study the interesting case in this model, we assume that this assumption is fulfilled.

4.1.4 Demand

Agricultural goods are a subsistence need, while the demand for modern goods depends on how many modern goods there are and how much income is left after the subsistence consumption. Total supply must equal total demand for agricultural goods. Supply is given by $(1-\mu)$ since this is the share of farmers who are assumed to produce with CRS. This implies that aggregated regional demand for agricultural goods in region $j = 1, 2$ is given by total supply $(1 - \mu)$ times the share of the population in the region, N_j.[14]

$$X_{Aj} = N_j(1 - \mu) \tag{5}$$

Aggregated regional demand for modern goods is decided by the excess income after consumption of agricultural goods and then equally distributed between the n modern goods. Thus, the total demand for modern goods in a region j, X_{Mj}, is then given by:

$$X_{Mj} = Y_j - N_j(1 - \mu) \tag{6}$$

This demand function varies with regional income Y_j and the population size in a region N_j, which are variables that depend on the choice of technology and the localization of economic activity.

4.1.5 Income

All workers receive a wage income of one, and some of the modern workers are shareholders that receive an additional profit income. Thus, income in a region j is given by the sum of wage and profit income of its inhabitants, as stated in equation (7).

$$Y_j = N_j + \Pi_j \tag{7}$$

Since the share of the population is normalized to one, the wage income in a region is equal to the population size in that region, N_j. There are always $\frac{1-\mu}{2}$ agricultural workers in each region, but where the μ modern workers live depends on where the modern industry is localized and which technology it uses. The profit income Π_j goes to the shareholders,

[14]The range of N_j is $\frac{1-\mu}{2} \leq N_j \leq \frac{1+\mu}{2}$, depending on where economic activity is located.

and its size will depend on firms' decisions about technology and localization. We will now find the profit income Π_j, first for the case of full centralization, then for the case of full decentralization.

Profits with Full Centralization

Full centralization is the case where all industrial production is located in the same region, such that the total share of the population in this region becomes $\mu + \frac{1-\mu}{2} = \frac{1+\mu}{2}$, while the remaining share of immobile workers, $\frac{1-\mu}{2}$, live in the periphery. Firms sell modern goods in both regions at a price of 1, which implies that production must be with IRS since they are dependent on the markup to afford covering transport costs. Total profits for the shareholders in the case of full centralization is given by:

$$\Pi^C = X_M^C - L_M - T \tag{8}$$

X_M^C is the total production of modern goods in the case of full centralization, each of which is sold at a price of one. Due to the symmetry of firms, this must be equal to the sum of individual output, nX_{Mi}^C. Since all modern production stems from IRS, X_{Mi}^C can be solved for from the IRS factor function given by equation (4), which gives $X_M^C = \frac{\mu - n\alpha}{\beta}$ (see Appendix B.2).

L_M is the total wage cost in modern production, nL_{Mi}, which due to a wage of one equals the number of employees in the modern sector, $n\frac{\mu}{n} = \mu$. This pool of workers consists of those associated with fixed costs (”building the factory”) and those associated with variable costs (”operating the factory”).

T is the aggregated transport cost covered by modern firms, which can be found by using that $\frac{1-\tau}{\tau}$ is the cost per shipped good, and that the total demanded for modern goods in the periphery is given by $X_{Mij}^C = \frac{\mu(1-\mu)}{2n}$ (see Appendix B.3). The aggregated transport cost is then given by:

$$T = \frac{\mu(1-\tau)(1-\mu)}{2\tau} \tag{9}$$

Inserting for X_M^C, L_M and T into (8) in order to find aggregated profits for the shareholders when production is centralized in one region, Π^C, gives the following (see Appendix B.2):

$$\Pi^C = \frac{1}{\beta}\left[\mu(1-\beta) - n\alpha - \beta\frac{\mu(1-\tau)(1-\mu)}{2\tau}\right] \tag{10}$$

Profits per firm, π^C is thus given by:

$$\pi^C = \frac{1}{\beta}\left[\frac{\mu(1-\beta)}{n} - \alpha - \beta\frac{\mu(1-\tau)(1-\mu)}{2n\tau}\right] \tag{11}$$

These are the profits for the case of full centralization, which is an easier task to find than in the next case since there is no uncertainty regarding which technology that is used in modern firms. As we discussed, modern firms must unambiguously use IRS technology in order to afford the transport costs associated with full centralization.

Profits with Full Decentralization

In the case of *full decentralization*, it is not certain whether profit income exists at all, as it could be the case that all modern production uses CRS technology. The profit income is the highest when all firms produce with IRS technology, but in order for this to even be possible, we need to make the assumption that the market size is large enough for IRS production to be profitable.[15] This is not a problematic assumption, as the most interesting point of departure to use for later comparison with the profits under centralization is when decentralization is as profitable as possible.

Each of the n goods is produced by identical factories in each region, and the population size of each region is $N_j = \frac{1}{2}$. The profit income in each firm is equally distributed across shareholder(s) in each region.[16]

[15] Note: This assumption does not necessarily imply that it is individually profitable to produce with IRS if all other firms produce with CRS.

[16] Whether there is one or more profit recipient per plant does not affect the demand spillovers from increased profits, as demand depends on the total income and is unaffected by the income distribution within the region. However, the distribution of profits has implications for the welfare effects of industrialization, which will be addressed later.

The aggregated profit income is now given by the following:

$$\Pi^D = X_M^D - L_M \tag{12}$$

Regional demand X_M^D differs from the case of full centralization because total production changes when production is not centralized. Since the population size is fixed and there is a given number of firms, there is a given number of employees per firm. When firms split production between locations, the fixed costs per firm double from α to 2α, which combined with the trait of a given number of employees weakens the ability to exploit economies of scale. It can be shown that production now becomes $X_M^D = \frac{\mu - 2n\alpha}{\beta}$ (see Appendix B.4).

The number of modern workers per firm, L_M, is still given by μ, but now this labor is divided between the factories in the two regions.

Note that the transport costs are now excluded from the equation. This is because the local demand is covered by local factories, such that no modern goods need to be transported between regions.

Inserting for X_M^D and L_M into equation (12) gives the following (see Appendix B.4):

$$\Pi^D = \frac{1}{\beta}\left[\mu - 2n\alpha - \beta\mu\right] \tag{13}$$

In order to find the profits per firm, π^D, we divide the expression by n:

$$\pi^D = \frac{1}{\beta}\left[\frac{\mu}{n}(1-\beta) - 2\alpha\right] \tag{14}$$

We have now derived the profits for the case of full decentralization while assuming the most interesting point of departure, namely that all production in Modern has IRS technology.

4.2 Localization: The Stability of Equilibria

In this model, the real decision-makers when it comes to the localization of economic activity are the shareholders in each firm. They choose between opening their factory in both regions to avoid transport costs or opening it in only one region to avoid additional fixed costs. Once factories are built, modern workers reside where they can find jobs, creating a home market demand in their region of residence. Thus, it is the profits facing the shareholders that determines the stability properties of the equilibria in the model.

There are two possible equilibria that represent extreme cases of the localization of the modern industry, respectively full centralization, and full decentralization. These are stable if it is not profitable for one individual firm to deviate from how the rest of the industry is organized. Since firms are symmetric, the equilibria become unstable as long as the benefits outweigh the costs of deviating for one firm.

By comparing individual costs and benefits of deviations from these states, we can derive expressions for the level of transport costs per unit which makes deviation the best option for a single firm. Since firms are symmetric, the same behavioral pattern applies to all other firms in the economy.

4.2.1 Deviation from Centralization

Firstly, we derive the condition for when firms will deviate from an initial state of full centralization. When an individual firm deviates from centralization by splitting its production between the two regions, there is a *cost reduction effect* and a *cost increase effect*.

The Cost Reduction Effect

The cost reduction effect of opening a plant in the periphery is that the firm no longer has to cover any transport costs. Using the assumption that the individual firm is too small to affect demand and regional population size, the total transport costs for the case of centralization is given by equation (9). The individual firm's cost reduction effect is thus found by dividing this expression by the number of firms n, which gives the following:

$$\frac{\mu(1-\tau)(1-\mu)}{2n\tau}$$

The Cost Increase Effect

The cost increase effect captures that an additional number of the firm's resources must be spent to cover fixed costs, which will weaken the benefits of scale. Covering these extra fixed costs involves a cost increase which is comprised of two components:

1. *The direct cost component:* Opening an additional factory involves covering a fixed cost $\alpha > 0$, measured in labor units. This can be thought of as "building the factory."
2. *The alternative cost component:* Spending α labor units on fixed costs means spending less labor on producing goods. Since goods are sold at a price of one, there is a loss equal to the marginal productivity of $\frac{1}{\beta} > 1$ for each of the α workers who no longer work with producing goods.

In total, the cost increase associated with establishing an additional factory is given by the product of the direct cost component α and the alternative cost component $\frac{1}{\beta}$:

$$\frac{\alpha}{\beta}$$

This was an intuitive explanation of the cost increase effect. Using the assumption that the individual firm is too small to affect demand and regional population size, it can also be derived analytically (see Appendix B.6).

Stability of Full Centralization

We can use the cost reduction effect and the cost increase effect to find the stability of full centralization as an economic equilibrium. If the cost reduction associated with deviation is lower than the cost increase, full centralization is a stable equilibrium. If the cost reduction associated with deviation is higher than the cost increase, full centralization is an unstable equilibrium. Mathematically:

$$\frac{\mu(1-\tau)(1-\mu)}{2n\tau} < \frac{\alpha}{\beta} \quad \Longrightarrow \text{Centralization is stable}$$
$$\frac{\mu(1-\tau)(1-\mu)}{2n\tau} > \frac{\alpha}{\beta} \quad \Longrightarrow \text{Centralization is unstable}$$

We rewrite the first expression in order to define what level of transport cost per good makes centralization stable:

$$\frac{1-\tau}{\tau} < \frac{2n\alpha}{\mu(1-\mu)\beta} \qquad (**)$$

It is evident from $(**)$ that full centralization is more likely to be stable when transport costs $\frac{1-\tau}{\tau}$ are low and when the benefits of scale $\frac{\alpha}{\beta}$ are high, either through higher fixed costs or through higher marginal productivity. Centralization is also more likely to be stable when the number of firms n is high, which is the same as each firm having a lower profit income. When the fixed number of workers in the economy is divided among more firms n, the output per firm will decline, leaving each firm with less surplus because it sells fewer goods. Thus, exploiting economies of scale by centralizing production becomes more important than avoiding transport costs when profits per firm are lower.

Furthermore, the effect of the share of modern workers μ is nonlinear on the stability of centralization, as it depends on whether μ is above or below $\frac{1}{2}$ (see Appendix B.7). On one hand, when $\mu < \frac{1}{2}$, an increased share of modern workers makes centralization less likely. On the other hand, when $\mu > \frac{1}{2}$, an increased share of modern workers makes centralization more likely. This non-linearity arises because there are two effects associated with changes in the composition of the labor force. The first effect, which dominates when $\mu < \frac{1}{2}$ is that as μ increases, the share of immobile workers decreases, which reduces the cost of shipping goods to the periphery. The second effect, which dominates when $\mu > \frac{1}{2}$ is that as μ increases, the number of workers per firm increases, which makes it easier for the firm to exploit the economies of scale while still covering the fixed costs for two factories.

4.2.2 Deviation from Decentralization

Next, we consider the profitability of a deviation from decentralization. Compared to having two firms producing the same good in each region, the firm owner now faces the choice of gathering all production in one location. This has a *cost reduction effect* due to better exploitation of the economies of scale,[17] but also a *cost increase effect* due to the associated transport costs. Which of these effects that dominates determines whether decentralization is a stable equilibrium or not.

The Cost Reduction Effect

The cost reduction effect due to better exploitation of economies of scale is equal to the cost increase effect found for the case of deviation from centralization. This is because the firm, rather than losing the ability to produce $\frac{\alpha}{\beta}$ units, now gains the ability to produce them by gathering its production in one location.[18] The cost reduction effect is thus given by:

$$\frac{\alpha}{\beta}$$

The Cost Increase Effect

In order to find the cost increase effect due to higher transport costs, we use that the demand from the region losing its plant is given by $X^D_{Mij} = \frac{\mu - 2n\alpha}{2n\beta}$ (see Appendix B.5 for derivation) and that the cost per shipped good is $\frac{1-\tau}{\tau}$. The cost increase effect due to the transport costs is given by the product of the cost per shipped good and the demand from the other region:

$$\frac{1-\tau}{\tau}\left(\frac{\mu - 2n\alpha}{2n\beta}\right)$$

[17] The assumption that the firm is too small to affect demand and regional population size still applies.

[18] Note the implicit assumption that the fixed costs are not sunk.

Stability of Full Decentralization

We then use the expressions for the cost reduction effect and the cost increase effect to determine the stability of full decentralization:

$$\frac{\alpha}{\beta} < \frac{1-\tau}{\tau}\left(\frac{\mu - 2n\alpha}{2n\beta}\right) \quad \Longrightarrow \text{Decentralization is stable}$$
$$\frac{\alpha}{\beta} > \frac{1-\tau}{\tau}\left(\frac{\mu - 2n\alpha}{2n\beta}\right) \quad \Longrightarrow \text{Decentralization is unstable}$$

The level of transport cost per good which makes decentralization stable must thus be given by the following:

$$\frac{1-\tau}{\tau} > \frac{2n\alpha}{\mu - 2n\alpha} \qquad (***)$$

We see from $(***)$ that decentralization is more likely to be stable when transport costs $\frac{1-\tau}{\tau}$ are high and when the fixed costs α are low, irrespective of the alternative cost $\frac{1}{\beta}$. Decentralization is also more likely to be stable when the number of firms n is low, which is the same as each firm having a higher profit income. When the fixed number of workers in the economy is divided among fewer firms n, the output per firm is higher, allowing each firm to sell more goods and achieve a higher surplus. Evidently, avoiding transport costs by decentralizing production becomes more important than exploiting economies of scale when the profits per firm are higher.

When Bjorvatn (1999) finds expressions that define whether firms will deviate from centralization, he defines profits in the case of doing the same as all other firms and compares these with the profits from deviating. Expression $(**)$ and $(***)$ were found in a simpler way, by only comparing the cost increases and the cost decreases associated with deviation. However, it is possible to derive the exact same thresholds by using Bjorvatn's approach (see Appendix B.8).

4.2.3 Overlapping Equilibria

It can be shown (see Appendix B.9) that the following must hold:

$$\frac{2n\alpha}{\mu - 2n\alpha} < \frac{2n\alpha}{\mu(1-\mu)\beta}$$

When transport costs are higher than the value of the fraction at the left-hand side, condition $(***)$ holds, which implies that full decentralization is stable (denoted by "D"). When transport costs are lower than the value of the fraction at the right-hand side, condition $(**)$ holds, which implies that full centralization is stable (denoted by "C"). Figure 5 illustrates that the inequality above implies an overlap of stable equilibria where both full centralization and full decentralization can be possible simultaneously (denoted by "C, D"). Since both are stable, this implies that if the economy starts out in one of the equilibria, it is difficult to move to the other because it will return to its initial state even after experiencing economic shocks.

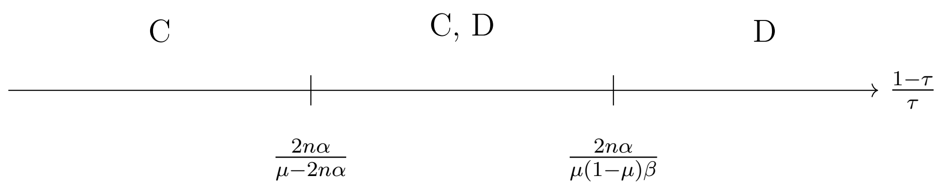

Figure 5: Overlapping equilibria

The horizontal axis measures the transport cost per unit, increasing towards the right.

Suppose that income (and consequently welfare) varies between the two equilibria that are simultaneously possible. If such is the case, we have identified the existence of a stable yet sub-optimal equilibrium. This would indicate the opportunity for a Pareto improvement[19] through a Big Push policy reform. In the next subchapter we investigate whether this is the case by comparing aggregate income in the two equilibria.

[19] *Pareto improvement*; When the reallocation of goods harms no individual and benefits at least one.

4.3 Welfare: The Big Push Mechanism

When we evaluate which localization of activity that yields the highest utility (within the area where multiple equilibria exist), we should keep in mind that the increase in utility only applies to shareholders. All workers who are not shareholders face the same income (both in real and nominal terms), irrespective of the localization of economic activity and the size of the profit income that goes to the shareholders. Thus, the only agents in the economy which can experience welfare changes are the shareholders, making it sufficient to compare their profit incomes to find the Pareto optimal equilibria.

It can be shown (see Appendix B.10) that the total profits are higher in the case of full centralization than in the case of full decentralization as long as $\frac{1-\tau}{\tau} < \frac{2n\alpha}{\mu(1-\mu)\beta}$, which is equal to the threshold defining that full centralization is a possible equilibrium in the first place. In other words, as long as centralization is a possible equilibrium, this is always the optimal state of the economy. This implies that within the interval of "Multiple equilibria" illustrated in Figure 5, full centralization is unambiguously the Pareto optimal equilibrium, even though we have assumed decentralization to be as profitable as possible. Thus, we have shown that there is room for a Big Push policy reform for economies that are stuck in poverty traps.

4.4 Takeaways from the Model of Geographic Centralization or Decentralization

In this chapter we have looked at an extended version of the basic model provided by Krugman. Before we specifically compare these two models in the next chapter, some key areas where the extended model differs from other basic NEG models are worth mentioning. These areas are the simplicity of the utility function and the new way to identify a Big Push mechanism.

4.4.1 The Simplicity of the Utility Function

The way the utility function is specified in this model, which differs from previous contributions to NEG, has the benefit of allowing for greater mathematical simplicity. Although the model is characterized by monopolistic competition, which is in line with previous contributions, we achieve this form of competition by assuming that there is a constant number of firms, rather than having the utility function imply consumers' "love of variety" for differentiated modern goods. The choice we make of assuming a given number of firms is in line with Big Push models (e.g. Murphy et al., 1989), and it allows for specifying a different utility function that can have other properties and that is mathematically simpler.

The way we choose to specify the utility function ensures that when income increases, the excess income will only be spent on the consumption of modern goods. Thus, increased income only contributes to an expansion of modern production, which ensures that constant shares of the population are employed in each sector, regardless of the state of the economy. If some of the increased income was directed towards agricultural goods, too, this would result in the need of an expansion of agricultural production. However, agricultural production cannot expand without adding more workers because it is unambiguously characterized by CRS. Modern production, on the other hand, can expand without the addition of more workers, either by industrializing or by choosing more efficient ways to organize production. Thus, the way the utility function is specified in the extended model allows for the assumption that constant shares of the population are employed in modern production and agriculture, which is a trait of the model that contributes to making the profit functions simpler.[20]

[20]Remember that we used the number of workers in each modern firm to determine wage costs when deriving the profit functions. Thus, when the number of workers in each sector is irrespective of the state of the economy, the derivation of the profit functions becomes substantially simpler.

4.4.2 The New Big Push Mechanism

The extended model not only offers a threshold for when centralization of economic activity is possible, but it also offers a threshold for when decentralization of economic activity is possible. This allows for the identification of overlapping equilibria, which shows that a Big Push investment can lift the economy out of a poverty trap. Thus, the model not only functions as a description of the historical economic outcomes of regions but also offers policy implications for how to affect historically predetermined economic pathways.

Furthermore, the identification of the multiple equilibria is shown without the presence of a wage premium or the stringent assumption that there are only two goods in the economy. Bjorvatn (1999) uses a NEG model with one modern good to show that a Big Push investment can stimulate the economy to reach the optimal equilibrium, conditional on the assumption that some of the profit income in the modern sector would accrue to the workers through a wage premium (p. 52-53). Workers will then move to whichever region that offers the highest wage. In the extended model presented in this thesis, it has been shown that it is possible to identify the room for a Big Push in a NEG model through the assumption that modern workers move wherever jobs are offered, rather than the assumption that they move to the region that offers the highest modern wage.

5 Discussion

This thesis aims to answer the following question:

Why is Paul Krugman's model from the first chapter of "Geography and Trade" not analytically solvable, and what insights about the spatial localization of workers and firms hold in an analytically solvable extension of the model?

It is difficult to answer the first part of this question without properly understanding some of the central differences between the implementation strategies in the two models. Therefore, comparing which traits the models capture and how they capture these traits will be the starting point for answering the thesis question. After this comparison, I will argue that there are two issues with the general equilibrium in the Krugman model, the endogeneity problem being the most serious of these two. Then follows a discussion of which insights that hold in the analytically solvable extension of the model. Finally, we will discuss some implications that this thesis provides for future research on NEG.

5.1 Comparison of the Models

There are two important differences between the nature of the models, which contribute to explaining the issues with the general equilibrium in the Krugman model. One key difference is whether the models specify how many firms that are allowed to compete in the market. The other key difference is demand specification - and which factors that are allowed to affect demand.

5.1.1 Competition and the Number of Firms

Krugman's basic model does not make any assumptions about how many firms that are allowed to enter the market, leaving the number of firms to be either fixed or flexible. In contrast, the extended model explicitly assumes a fixed number of firms. If the assumptions regarding the number of firms differ between the models, this implies that the nature of competition differs as well.

Under the assumption of a fixed number of firms, firms can increase profits by industrializing and locating production to induce the lowest costs and the highest returns. Even though centralization is the equilibrium yielding the highest total profits in the extended model, the individual opportunity for choosing to gather production depends on whether enough other individual firms have done the same. This implies that total profits (and consequently total income) varies depending on how the firms have localized production and whether they have industrialized.

Under the assumption of a flexible number of firms, firms will establish as long as there are profits to achieve. For every additional establishment, profits per firm decline, and new firms continue to enter the market until there is no more profit income to seek. If the conditions change because firms reorganize production and become more effective, the opportunity for achieving a profit income re-emerges, allowing additional firms to enter the market until profits are driven to zero again. Thus, the total income in any stable equilibrium is always equal to the wage income when we assume a flexible number of firms.

In a monopolistic competition framework, having a fixed number of firms implies the possible existence of a profit income in a stable equilibrium, and having a flexible number of firms implies that there is no profit income in equilibrium. The remaining question is how the nature of demand is affected by the two types of assumptions about the establishment of firms.

5.1.2 The Specification of Demand

In a model where the transportation of modern goods between regions may occur, specifying the demand these regions have for modern goods is crucial. Intuitively, a demand function should capture how much income consumers have to spend and how they spread this income between the consumption of goods. Both models have in common that they disregard savings and assume that consumers spend all income on consumption. However, they differ in how they account for demand and income. That is, Krugman's model does not have a demand or income function, whereas the extended model does. Krugman simply assumes that a variable x can capture the total sales from each firm. The extended model specifies demand and income functions that differ depending on where economic activity is located and what technology the modern firms have chosen to use. The implications of these specifications illustrate what is problematic about the x variable in the Krugman model.

In the extended model, there is an income function given by equation (7) which depends on wages and a profit income, implying that when firms exploit economies of scale more effectively[21] in a region, profits increase such that the total income in this region increases. The demand function specifies that after consumers have met a subsistence consumption of agricultural goods, all excess income is evenly spread between the modern goods. This link between the demand and income function ensures that better exploitation of economies of scale contributes to an increased demand for modern goods.

In the basic Krugman model, there is no link between demand and income because he treats the total sales from each firm, x, as an exogenous variable. However, no matter what the nature of competition is, demand should depend on the choice of technology and the localization of the industry. If there is a fixed number of firms in the Krugman model, income is flexible, and the nature of demand is like the one in the extended model. If there is a flexible number of firms in the Krugman model, income is fixed, implying that the demand per firm declines when more firms establish. Thus, regardless of which assumption about the number of firms he imposes, x is an endogenous variable that depends on how the industry is organized. In the next subchapter we look at two issues associated with Krugman's expression of the general equilibrium, and the endogeneity of x is the source of the most problematic one of these.

[21] Note that more effective exploitation of economies of scale both can happen through the choice of technology *and* where to localize production.

5.2 Issues with Krugman's General Equilibrium

When we compare the models' expressions for the thresholds defining the stability of full centralization as an equilibrium, we see that there are two issues with Krugman's approach, one of which is particularly problematic. For reference, the threshold for the possibility of centralization is given by ($*$) in Krugman's model and the threshold for the stability of centralization is given by ($**$) in the extended model.

$$t < \frac{2F}{x(1-\pi)} \tag{$*$}$$

$$\frac{1-\tau}{\tau} < \frac{2n\alpha}{\mu(1-\mu)\beta} \tag{$**$}$$

The first problem with condition ($*$) is that one of the exogenous terms that should be part of the expression lacks. The second problem is that it contains an endogenous term. Both expressions were found based on the cost effects associated with deviation from full centralization. Table 1 compares the cost components used to derive the thresholds in each of the models.

Table 1: Comparison of Costs of Deviation from Full Centralization

	Cost increase	Cost reduction
Basic model	F	tS_Nx or $t(1-S_N)x$
Extended model	$\frac{\alpha}{\beta}$	$\frac{\mu(1-\tau)(1-\mu)}{2n\tau}$

Note that although the basic Krugman model uses two different components to capture the cost reduction of deviating from full centralization (depending on which region that is initially centralized), the derived threshold specified by ($*$) applies regardless of which region that is centralized. In order to explain the two issues with the Krugman model, we compare the components capturing the cost increase and cost reduction one by one.

5.2.1 The Cost Increase Effect

The cost increase component captures the costs associated with opening an additional factory. Krugman represents them by F in the basic model, where F is the fixed cost associated with establishing another factory. We capture them by $\frac{\alpha}{\beta}$ in the extended model, where α represents the fixed costs and $\frac{1}{\beta}$ represents the alternative costs associated with weaker exploitation of economies of scale. Krugman never specifies any production (or factor) function but claims that there are IRS in modern production, which implies a cost of F for opening an additional factory. However, his cost increase component does not account for the alternative cost associated with weaker exploitation of economies of scale. If there is no alternative cost associated with spending less labor on the actual production of goods, it must be the case that the marginal productivity equals one. However, this is inconsistent with the alleged IRS properties in the modern industry.

Though this comparison illustrates an issue with the Krugman model, we should note that this issue does not result in severe consequences. If Krugman had used a factor function like the one defined by (4) in the extended model, the only consequence would be that the right-hand side of $(*)$ would contain an additional exogenous variable capturing the alternative cost, like $\frac{1}{\beta}$ does in expression $(**)$. Alternatively, we can interpret the F variable as a composite term with an underlying equation that both captures the direct fixed cost and the associated alternative cost. We find the more serious issue with the basic Krugman model by examining the component capturing the cost reduction effect.

5.2.2 The Cost Reduction Effect

A firm that deviates from centralization will no longer have to cover transport costs for shipping goods to the periphery. Both models use a similar logic to find these costs; they define a transport cost per unit shipped, and multiply this by the demand from the periphery which depends on how many inhabitants reside there. However, Krugman incorporates demand from the periphery by multiplying the share of the population in the periphery by the total demand for the firm's goods, x. As argued, x must be an endogenous variable as long as a profit income exists in the economy. This means that threshold ($*$) contains an endogenous variable, and thus the general equilibrium model is not analytically solvable in such a case. In the extended model, this is not an issue because demand from the periphery has been explicitly derived (see Appendix B.3).

5.3 What Insights Sustain?

Though the basic Krugman model faces a serious endogeneity issue, it provides some results that hold in the analytically solvable extension. Though he does not show it with his basic model, the exogenous general equilibria in the extended model confirm his claim that "the concentration of production is arbitrary, and can be presumed to be a function of initial conditions or historical accident" (Krugman, 1991a). We will discuss what particular insights that sustain, but since Krugman does not find an expression for the stability of decentralization, the focus is on the insights about centralization.

When we compare the thresholds that define when centralization is stable, ($*$) and ($**$), it is clear that many of the predictions are the same. In both models, factors that contribute to centralization are a higher degree of economies of scale and lower transport costs. However, there are also some differences. In the Krugman model, there is an unambiguously positive effect of more modern workers on the probability of centralization. In the extended model, this effect is only positive until the share of modern workers exceeds 50%. In addition, the extended model predicts that the higher number of firms (implying less profits per firm), the more centralization. If Krugman's x variable was not expected to be endogenously dependent on the organization of economic activity, it could be interpreted as capturing the same effect, namely that there is more centralization when there are more firms, captured through a lower demand x directed at each firm.

We see that the models do have some similar predictions, but it is important to emphasize that these predictions rely on the assumptions made - which are rather similar. Thus, even though the models have isolated some effects that are present under these very simplified economies, many implementation strategies can isolate other important explanatory factors for the spatial localization of economic activity and may yield contradictory predictions.

5.4 Future Research

In this thesis, we have paid much attention to the drawbacks to Krugman's model, but this does not mean that the extended model is flawless. There are many shortcomings and overlooked factors in the extended model, and addressing all of these could have been the subject of an entire master's thesis. Notwithstanding, this subchapter provides a brief overview of some of the most immediate areas of improvement. These areas of improvement will also identify the potential for future research on NEG.

5.4.1 Less Restrictive Implementation of Monopolistic Competition

Though Dixit and Stiglitz (1977) contribute with a framework that makes it easier to incorporate imperfect competition in economic models, this framework is still accompanied by stringent assumptions about firm behavior. In line with Big Push literature, the extended model in this thesis explores the idea of assuming that there is a given number of firms in the economy in order to capture the role of profits. Making this assumption is analytically convenient but not intuitively logical. The thresholds that define the stability of equilibria given by $(**)$ and $(***)$ both depend on the number of firms, n. However, if there is weak support for assuming that the number of firms is fixed, the extended model presented in this thesis possesses an endogeneity issue similar to the one identified in Krugman's model.

Nonetheless, we can argue that the x component in Krugman's basic model is more likely to be endogenous than the n component in the extended model. It seems less restrictive to assume that there are barriers to entry of new firms than assuming that income is unaffected by the exploitation of economies of scale, or that the demand for modern goods is unaffected by income levels. Thus, though there is good reason to criticize the unrealistic assumption of a given number of firms in the extended model, there is even more reason to criticize the supposition that demand is exogenous in the Krugman model.

As we can see, there are issues with the way both models simplify the nature of competition. Inspired by this observation, an interesting research question is whether other theoretical implementation strategies can ensure a less criticizable yet simple implementation of monopolistic competition. If such a strategy exists, it would be interesting to use it to create a similar model to the extension in this thesis and then discuss their results about the localization of economic activity.

5.4.2 The Role of Transport Costs

As introduced in chapter 2, the debate about the effect of transport costs on centralization at the regional level is unsettled. Both models we see in this thesis predict that when the unit cost component of the transport costs declines, centralization of economic activity becomes more likely. However, since the models implement the sources of agglomeration and dispersion in the same manner, these results provide little insight into the debate on the role of transport costs in NEG.

The more interesting topic to investigate is how the predicted role of transport costs in NEG models responds to *different* implementation strategies. As we saw in chapter 2, simulations based on the model provided by Helpman (1995) predict that the probability of decentralization increases with lower transport costs. This is the opposite of the results obtained by the two models presented in this thesis. One key difference between the implementation strategies in these models is that Helpman uses an immobile supply source as a force of dispersion, while the two models presented in this thesis use an immobile source of demand. Another important difference is that workers always move where firms choose to locate in the models presented in this thesis, whereas they move to the region offering the best consumption in the Helpman model.

The discrepancies in the models' results motivate creating an analytically solvable model which is similar to the extended model in this thesis, but where the source of dispersion is immobile supply. Regardless of what insights such a model gives on the role of transport costs, it would be a unique methodological contribution to have two comparable and analytically solvable models that we can use to compare the consequences of different implementation strategies on predicted effects.

5.4.3 Clear and Relevant Predictions

In general, this thesis shows that it is possible to create an analytically solvable NEG model without compromising substantially on the central dynamics that the model should possess. Using the extended model presented in chapter 4 for inspiration, it should be possible to create other analytically solvable NEG models which focus on new assumptions and implementation strategies. Whether these contributions focus on the role of transport costs, different ways to account for agglomeration and dispersion forces, new ways to implement monopolistic competition, or other variations to the framework, the hope is that they will contribute with new predictions on what affects the localization of economic activity.

Furthermore, these models have the potential to do more than just describe the historical emergence of industrial regions in developing economies. Though predictions about an economy that is highly dependent on agriculture with CRS technology may seem to have little relevance for developed economies, we can easily draw lines to local services with little room for technological innovation. For instance, the models are relevant for explaining how the localization of labor-intensive sectors like education, local government, and health services affect the regional localization of economic activity. Thus, they are both relevant for developed and developing economies. Additionally, we can use the NEG models that identify the room for a Big Push to discuss how policies can increase total welfare, and to decompose who actually gains from this increased welfare.

6 Conclusion

The title of this thesis reads "Putting Simplicity Back Into New Economic Geography." Because the methodological contribution is a theoretical model which is more complex than the one offered by Paul Krugman, this title may seem unsuited. However, the intention is not to imply that this model is simpler than Krugman's. Instead, the intention is to emphasize that it is possible to offer an analytically solvable model of New Economic Geography, using a more simplistic framework than similar contributions. Forslid and Ottaviano (2003) picks up the Core-Periphery model Krugman publishes in the Journal of Political Economy in 1991 when they provide an analytically solvable version. However, no such contribution has been made based on the simplest model Krugman offers - until now.

Two characteristics, in particular, have contributed to making the extended model in this thesis analytically solvable. Firstly, there is the assumption of a given number of firms. Secondly, there is the utility function which ensures that all excess income after a subsistence consumption of agricultural goods is evenly divided between the modern goods. Together, these assumptions allow for monopolistic competition while still ensuring mathematical simplicity. Furthermore, the utility function ensures that fixed shares of the population are always employed in each industry, irrespective of the expansion of the modern industry. Krugman never discusses this issue when he presents his model, but in the extended model it is of central importance for making the model solvable.

We have seen that the Krugman model has an endogeneity issue, making the expression he derived for the general equilibrium invalid. However, many of his conclusions on how central parameters affect centralization still seem to hold in the extended model. This is not surprising, since the two models make many similar assumptions. Thus, an analytically solvable model which deviates more from the assumptions posed by Krugman's model would be a valuable contribution to the discussion about the spatial localization of economic activity.

References

Baldwin, R. E., & Martin, P. (2004). Agglomeration and regional growth. In J. V. Henderson & J. F. Thisse (Eds.), *Handbook of Regional and Urban Economics* (pp. 2671–2711). Elsevier. https://ideas.repec.org/h/eee/regchp/4-60.html

Bjorvatn, K. (1999). Third world regional integration. *European Economic Review*, *43*(1), 47–64. https://EconPapers.repec.org/RePEc:eee:eecrev:v:43:y:1999:i:1:p:47-64

De Blasio, G., & Di Addario, S. (2005). Do workers benefit from industrial agglomeration?*. *Journal of Regional Science*, *45*(4), 797–827. https://doi.org/https://doi.org/10.1111/j.0022-4146.2005.00393.x

Dixit, A. K., & Stiglitz, J. E. (1977). Monopolistic competition and optimum product diversity. *The American Economic Review*, *67*(3), 297–308. http://www.jstor.org/stable/1831401

Faghih, N. (2019). An introduction to: Globalization and development—entrepreneurship, innovation, business and policy insights from asia and africa. https://doi.org/10.1007/978-3-030-11766-5_1

Forslid, R., & Ottaviano, G. I. (2003). An analytically solvable core-periphery model. *Journal of Economic Geography*, *3*(3), 229–240. https://doi.org/10.1093/jeg/3.3.229

Fujita, M., & Krugman, P. (1995). When is the economy monocentric?: Von thünen and chamberlin unified [Recent Advances in Urban Economics and Land Use: A Special Issue in Honour of Hiroyuki Yamada]. *Regional Science and Urban Economics*, *25*(4), 505–528. https://doi.org/https://doi.org/10.1016/0166-0462(95)02098-F

Fujita, M., & Krugman, P. (2003). The new economic geography: Past, present and the future. *Economics of Governance*, *83*(1), 139–164. https://EconPapers.repec.org/RePEc:spr:ecogov:v:83:y:2003:i:1:p:139-164

Fujita, M., & Thisse, J.-F. (2003). Does geographical agglomeration foster economic growth? and who gains and loses from it? *The Japanese Economic Review*, *54*(2), 121–145. https://doi.org/https://doi.org/10.1111/1468-5876.00250

Gabaix, X., Laibson, D., Caplin, A., & Schotter, A. (2008). The seven properties of good models. *The methodologies of modern economics: Foundations of positive and normative economics*. Oxford University Press.

Gaspar, J. M. (2021). New economic geography: History and debate. *The European Journal of the History of Economic Thought*, *28*(1), 46–82. https://doi.org/10.1080/09672567.2020.1767671

Gregori, T. (2021). Protectionism and international trade: A long-run view. *International Economics*, *165*, 1–13. https://doi.org/https://doi.org/10.1016/j.inteco.2020.11.001

Helpman, E. (1995). The size of regions," *Topics in Public Economics. Theoretical and Applied Analysis*, (14-95). https://ideas.repec.org/p/fth/teavfo/14-95.html

Krugman, P. (1980). Scale economies, product differentiation, and the pattern of trade. *The American Economic Review*, *70*(5), 950–959. http://www.jstor.org/stable/1805774

Krugman, P. (1991a). *Geography and trade*. The MIT Press.

Krugman, P. (1991b). Increasing returns and economic geography. *Journal of Political Economy*, *99*(3), 483–499. http://www.jstor.org/stable/2937739

Krugman, P. (2009). The increasing returns revolution in trade and geography. *American Economic Review*, *99*(3), 561–71. https://doi.org/10.1257/aer.99.3.561

Krugman, P. (2011a). The new economic geography, now middle-aged. *Regional Studies*, *45*(1), 1–7. https://doi.org/10.1080/00343404.2011.537127

Krugman, P. (2011b). The new economic geography, now middle-aged. *Regional Studies*, *45*, 1–7. https://doi.org/10.1080/00343404.2011.537127

Krugman, P., & Elizondo, R. L. (1996). Trade policy and the third world metropolis [Increasing Returns, Monopolistic Competition and Economic Development]. *Journal of Development Economics*, *49*(1), 137–150. https://doi.org/https://doi.org/10.1016/0304-3878(95)00055-0

Krugman, P., & Venables, A. J. (1995). Globalization and the Inequality of Nations*. *The Quarterly Journal of Economics*, *110*(4), 857–880. https://doi.org/10.2307/2946642

Marshall, A. (1920). *The principles of economics*. McMaster University Archive for the History of Economic Thought. https://EconPapers.repec.org/RePEc:hay:hetboo:marshall1890

Mossay, P. (2013). A theory of rational spatial agglomerations. *Regional Science and Urban Economics*, *43*(2), 385–394. https://doi.org/10.1016/j.regsciurbeco.20

Murphy, K. M., Shleifer, A., & Vishny, R. W. (1989). Industrialization and the big push. *Journal of Political Economy*, *97*(5), 1003–1026. http://www.jstor.org/stable/1831884

Ottaviano, G. I. P. (2010). 'New' new economic geography: firm heterogeneity and agglomeration economies. *Journal of Economic Geography*, *11*(2), 231–240. https://doi.org/10.1093/jeg/lbq041

Pflüger, M., & Südekum, J. (2008). Integration, agglomeration and welfare. *Journal of Urban Economics*, *63*(2), 544–566. https://doi.org/https://doi.org/10.1016/j.jue.2007.03.006

Redding, S. J. (2016). Goods trade, factor mobility and welfare. *Journal of International Economics*, *101*, 148–167. https://doi.org/https://doi.org/10.1016/j.jinteco.2016.04.003

Redding, S. J. (2020). *Trade and geography* (Working Paper No. 27821). National Bureau of Economic Research. https://doi.org/10.3386/w27821

Redding, S. J., & Rossi-Hansberg, E. (2017). Quantitative spatial economics. *Annual Review of Economics*, *9*(1), 21–58. https://doi.org/10.1146/annurev-economics-063016-103713

Samuelson, P. A. (1954). The Transfer Problem and Transport Costs, II: Analysis of Effects of Trade Impediments. *The Economic Journal*, *64*(254), 264–289. https://doi.org/10.2307/2226834

Tabuchi, T., & Thisse, J.-F. (2002). Taste heterogeneity, labor mobility and economic geography. *Journal of Development Economics*, *69*(1), 155–177. https://doi.org/https://doi.org/10.1016/S0304-3878(02)00057-3

Venables, A. J. (1993). *Equilibrium Locations of Vertically Linked Industries* (CEP Discussion Papers dp0137). Centre for Economic Performance, LSE. https://ideas.repec.org/p/cep/cepdps/dp0137.html

A Appendix: The Basic Model

A.1 The MM curve: Analytical explanation

The MM curve describes the localization of the manufacturing industry. It is based on the choices each modern firm makes about where to open factories in order to minimize costs. The firm can end up in three different situations:

1. It is cheaper to offer goods in West from a plant in East
2. It is cheaper to offer goods in East from a plant in West
3. Neither of the above applies, such that it is cheaper to have a plant in each region

Below follows conditions for when the firm is in each of these three situations.

A.1.1 Cheaper to Offer Goods In West From a Plant in East

$$tS_N x < F \tag{15}$$

The left-hand side of (15) represents the cost of not establishing in West, which is the cost of transporting goods from East. This is comprised of a unit transport cost t, and the share of population S_N[22] that demand their proportional share of the firm's supplied goods, x. The right-hand side represents the cost of establishing in West, which is equal to the fixed cost associated with opening a new factory. When (15) holds, there will be no manufacturing in West, such that $S_M = 0$. We rearrange (15) in order to leave S_N alone, and summarize this interpretation as the followng condition:

$$S_M = 0 \text{ if } S_N < \frac{F}{tx}$$

[22]Note that this implies that wage income must be equal for all workers

A.1.2 Cheaper to Offer Goods in East From a Plant in West

$$t(1 - S_N)x < F \tag{16}$$

This expression is almost identical to condition (15), except that the transport costs now cover a demand of $(1 - S_N)x$ from the population. When condition (16) holds, all manufacturing will be in West, such that $S_M = 1$. We rearrange equation (16) in order to leave S_N alone, and summarize this interpretation as the following condition:

$$S_M = 1 \text{ if } 1 - \frac{F}{tx} < S_N$$

A.1.3 Cheaper to Have a Plant in Each Region

It is cheaper to have a plant in each region if neither condition (15) nor condition (16) holds. This can be expressed mathematically as the following condition:

$$\frac{F}{tx} < S_N < 1 - \frac{F}{tx} \tag{17}$$

When firms divide all production equally between regions, all workers will also be equally divided between plants, such that $S_M = S_N$. This interpretation can be summarized as follows:

$$S_M = S_N \text{ if } \frac{F}{tx} < S_N < 1 - \frac{F}{tx}$$

A.1.4 The MM curve

The MM curve can thus be described by the following three conditions:

$$
\begin{aligned}
S_M &= 0 \text{ if } S_N < \frac{F}{tx} \\
&= S_N \text{ if } \frac{F}{tx} < S_N < 1 - \frac{F}{tx} \\
&= 1 \text{ if } 1 - \frac{F}{tx} < S_N
\end{aligned}
\tag{MM}
$$

B Appendix: The Extended Model

B.1 Transport Costs per Unit

Knowing that a share $(1-\tau)$ of a good has been lost during shipping, the transport cost per unit shipped is the *excess* amount shipped in order for one good to arrive. We find what x (amount shipped good) must be in order for 1 unit to arrive:

$$
\begin{aligned}
x\tau &= 1 \\
x &= \frac{1}{\tau}
\end{aligned}
$$

$\implies$ Firms must ship $\frac{1}{\tau}$ goods in order for one good to arrive.

We find the unit transport cost (per arrived good):

$$
\begin{aligned}
\text{Transport cost} &= \text{Shipped} - \text{Arrived} \\
&= \frac{1}{\tau} - 1 \\
&= \frac{1-\tau}{\tau}
\end{aligned}
$$

B.2 Deriving Profits with Full Centralization

Total profit for the shareholders during centralization, Π^C:

$$\Pi^C = X_M^C - L_M - T = nX_{Mi}^C - nL_{Mi} - nT_i \tag{8}$$

Total wage costs in modern production in the case of full centralization, L_M:

$$L_M = nL_{Mi} = n\frac{\mu}{n} = \mu$$

Total production of modern goods in the case of full centralization, X_M^C:

$$
\begin{aligned}
X_{Mi}^C &= \frac{L_{Mi} - \alpha}{\beta} \\
\implies X_M^C &= nX_{Mi}^C = n\frac{L_{Mi} - \alpha}{\beta} = \frac{nL_{Mi} - n\alpha}{\beta} = \frac{\mu - n\alpha}{\beta}
\end{aligned}
$$

Total transport costs in the case of full centralization, T:

$$
T = nT_i = n\frac{1-\tau}{\tau}X_{Mij}^C = n\frac{1-\tau}{\tau}\frac{\mu(1-\mu)}{2n} = \frac{\mu(1-\tau)(1-\mu)}{2\tau} \tag{9}
$$

Inserting for X_{Mi}^C, L_M and T into (8) in order to find aggregated profits for the shareholders when production is centralized in one region, Π^C:

$$
\begin{aligned}
\Pi^C =& \frac{\mu - n\alpha}{\beta} - \mu - \frac{\mu(1-\tau)(1-\mu)}{2\tau} \\
=& \frac{1}{\beta}\left[\mu(1-\beta) - n\alpha - \beta\frac{\mu(1-\tau)(1-\mu)}{2\tau}\right]
\end{aligned} \tag{10}
$$

Profits per firm, π^C is then given by:

$$
\begin{aligned}
\pi^C &= \frac{\Pi^C}{n} \\
&= \frac{\mu - n\alpha}{n\beta} - \frac{\mu}{n} - \frac{\mu(1-\tau)(1-\mu)}{2n\tau} \\
&= \frac{1}{\beta}\left[\frac{\mu(1-\beta)}{n} - \alpha - \beta\frac{\mu(1-\tau)(1-\mu)}{2n\tau}\right]
\end{aligned} \tag{11}
$$

B.3 Regional Demand From the Periphery with Centralization

When the transport costs under the case of full centralization are calculated, it is postulated that the demand from the periphery region is given by $X_{Mij}^C = \frac{\mu(1-\mu)}{2n}$. An explanation for this follows below.

Since all excess income is equally distributed between the consumption of the n modern goods (a trait which follows from the utility function), we have that $X_{Mij}^C = \frac{1}{n}X_{Mj}^C$.

Using this, together with equation (6), we can find the demand from the periphery. Since there is only wage income in the periphery, it must be equal to the population size, $Y_j^C = N_j^C \frac{1-\mu}{2}$. Implicit from equations (5) and (6), demand must equal supply of the agricultural goods produced by the $(1-\mu)$ farmers using CRS technology, meaning that the amount spent on subsistence consumption must be a share $(1-\mu)$ of this income.[23]

$$X_{Mij}^C = \frac{1}{n}\left(Y_j^C - N_j^C(1-\mu)\right) = \frac{1}{n}\left(\frac{1-\mu}{2} - \frac{1-\mu}{2}(1-\mu)\right) = \frac{\mu(1-\mu)}{2n}$$

B.4 Deriving Profits with Full Decentralization

Total profits for the shareholders during full decentralization, π^D:

$$\Pi^D = X_M^D - L_M = nX_{Mi}^D - nL_{Mi} \tag{12}$$

Equation (4) is reformulated in order to capture that each firm pays twice as large fixed costs in the case of full decentralization:

$$L_{Mi}^D = 2\alpha + \beta X_{Mi}^D \tag{4'}$$

The reformulation of (4) to (4') again affects regional demand X_M^D:

$$X_M^D = nX_{Mi}^D = \frac{\mu - 2n\alpha}{\beta}$$

[23]Note that the rest of the agricultural goods in the periphery are implicitly shipped to the centralized region with zero transportation costs.

Inserting for X_{Mi} and L_{Mi} into equation (12) gives the following:

$$\begin{aligned} \Pi^D &= \frac{\mu - 2n\alpha}{\beta} - \mu \\ &= \frac{1}{\beta}\left[\mu - 2n\alpha - \beta\mu\right] \end{aligned} \tag{13}$$

In order to find the profits per firm, π^D, the expression is divided by n:

$$\begin{aligned} \pi^D &= \frac{\Pi^D}{n} = \frac{1}{\beta}\left[\frac{\mu}{n} - 2\alpha - \frac{\beta\mu}{n}\right] \\ &= \frac{1}{\beta}\left[\frac{\mu}{n}(1-\beta) - 2\alpha\right] \end{aligned} \tag{14}$$

B.5 Regional Demand From the Periphery with Decentralization

When the transport costs under the case of full centralization are calculated, it is postulated that the demand from the periphery region is given by $X^D_{Mij} = \frac{\mu - 2n\alpha}{2n\beta}$. An explanation for this follows here.

All excess income is equally distributed between the consumption of the n modern goods, meaning that $X^D_{Mij} = \frac{1}{n} X^D_{Mj}$. Using this, together with equation (6), the demand from the periphery can be found. Now, income in the relevant region is the sum of wage income and profit income. The wage income is equal to the population size in the area, $N^D_j = \frac{1}{2}$, and the profit income is equal to half the aggregate profits during decentralization, $\frac{\Pi^D}{2}$. The expression for Π^D has already been found, and is given by equation (12).

Inserting for all this gives the following:

$$\begin{aligned}
X^D_{Mij} &= \frac{1}{n}\left[\left(\frac{1}{2}+\frac{\Pi^D}{2}\right)-\frac{1}{2}(1-\mu)\right] \\
&= \frac{1}{n}\left[\frac{\Pi^D}{2}+\frac{1}{2}\mu\right] \\
&= \frac{1}{n}\left[\frac{1}{2}\left(\frac{\mu-2n\alpha}{\beta}-\mu\right)-\frac{1}{2}\mu\right] \\
&= \frac{\mu-2n\alpha}{2n\beta}
\end{aligned}$$

B.6 Deviation from Centralization: The Cost Increase Effect

In subchapter 4.2.1, an intuitive explanation of the cost increase effect $\frac{\alpha}{\beta}$ associated with an individual firm's deviation from centralization is provided. Here, an analytical explanation is provided, using a comparison of the profit functions for the case of centralization and the case of decentralization. These functions are comparable given the assumption that regional demand and population size is unaffected by the relocation of one single firm.

The functions for π^C and π^D are given by the following:

$$\pi^C = X^C_{Mi} - L_{Mi} - T_i = \frac{\mu - n\alpha}{n\beta} - \frac{\mu}{n} - \frac{\mu(1-\tau)(1-\mu)}{2n\tau} \tag{11}$$

$$\pi^D = X^D_{Mi} - L_{Mi} = \frac{\mu - 2n\alpha}{n\beta} - \frac{\mu}{n} \tag{14}$$

There are two main differences between equation (11) and (14). Firstly, equation (11) subtracts transport costs, T_i. Secondly, equation (11) contains a production of X^C_{Mi}, whereas equation (14) contains a production of X^D_{Mi}.

A comparison of the production levels (which are the income sources since goods are sold at a price of one) illustrates why the cost increase associated with choosing decentralization must be given by $\frac{\alpha}{\beta}$:

$$X_{Mi}^{C} = \frac{\mu - n\alpha}{n\beta}$$
$$X_{Mi}^{D} = \frac{\mu - 2n\alpha}{n\beta} = \frac{\mu - n\alpha}{n\beta} - \frac{\alpha}{\beta}$$

As evident from the expressions for X_{Mi}^{C} and X_{Mi}^{D}, the associated income level per firm is $\frac{\alpha}{\beta}$ lower in the case of full decentralization than in the case of full centralization.

B.7 The Effect of Modern Workers on Centralization

The threshold defining that centralization is stable is given by $(**)$:

$$\frac{1-\tau}{\tau} < \frac{2n\alpha}{\mu(1-\mu)\beta} \tag{**}$$

The larger the right hand side, the more likely it is that $(**)$ holds, such that centralization is stable. We find derivative of the denominator on the right hand side of $(**)$, with respect to the share of modern workers, μ:

$$\frac{\partial \mu(1-\mu)\beta}{\partial \mu} = \beta \times (1-\mu) + \beta\mu(-1) = \beta - \beta\mu - \beta\mu = \beta(1-2\mu)$$

Since we have assumed that $0 < \beta < 1$, the sign of the partial derivative is decided by the sign of $(1-2\mu)$:

$$(1-2\mu) > 0 \text{ if } \mu < \frac{1}{2}$$
$$(1-2\mu) < 0 \text{ if } \mu > \frac{1}{2}$$

Since a larger denominator $\mu(1-\mu)\beta$ contributes to a lower value of the fraction, we have that an increase in μ contributes to less centralization when $\mu < \frac{1}{2}$, and to more centralization when $\mu > \frac{1}{2}$.

B.8 Alternative Derivation of Thresholds

Below follows a comparison of the firm's individual profits associated with organizing production between regions like all other firms, and the profits associated with deviation. Though this is another procedure than the one presented in chapter 4, it will yield the same expressions for the stability of equilibria, given by (∗∗) and (∗∗∗). Both derivations build on the assumption that population size and regional demand are unaffected by the re-localization of one firm.

B.8.1 The Threshold for Centralization

The individual profit associated with centralization is given by π^C, and the profit associated with deviating from it is given by π_d^C (where d denotes "deviation"):

$$\pi^C = \frac{1}{\beta}\left[\frac{\mu(1-\beta)}{n} - \alpha - \beta\frac{\mu(1-\tau)(1-\mu)}{2n\tau}\right] \tag{11}$$

$$\pi_d^C = \frac{\mu - n\alpha}{n\beta} - \frac{\mu}{n} - \frac{\alpha}{\beta} = \frac{1}{\beta}\left[\frac{\mu(1-\beta)}{n} - \alpha(1+\beta)\right]$$

The equation defining π^C was explained in chapter 4. The equation defining π_d^C assumes the same demand and labor usage as before, and has incorporated an additional cost of $\frac{\alpha}{\beta}$.

In order for it to be profitable to stay in full centralization, it cannot be more profitable to deviate. Thus, the stability of centralization expresses when $\pi^C > \pi_d^C$ holds:

$$\frac{1}{\beta}\left[\frac{\mu(1-\beta)}{n} - \alpha - \beta\frac{\mu(1-\tau)(1-\mu)}{2n\tau}\right] > \frac{1}{\beta}\left[\frac{\mu(1-\beta)}{n} - 2\alpha\right]$$
$$\alpha + \frac{\beta\mu(1-\tau)(1-\mu)}{2n\tau} < 2\alpha$$

$$\implies \frac{1-\tau}{\tau} < \frac{2n\alpha}{\mu(1-\mu)\beta} \tag{**}$$

B.8.2 The Threshold for Decentralization

The individual profit associated with centralization is given by π^D, and the profit associated with deviating is given by π_d^D (where d denotes "deviation"):

$$\pi^D = \frac{1}{\beta}\left[\frac{\mu}{n}(1-\beta) - 2\alpha\right] \tag{14}$$

$$\pi_d^D = \frac{\mu - 2n\alpha}{n\beta} - \frac{\mu}{n} - \frac{1-\tau}{\tau}\left(\frac{\mu - 2n\alpha}{2n\beta}\right) + \frac{\alpha}{\beta} = \frac{1}{\beta}\left[\frac{\mu(1-\beta)}{n} - \alpha - \frac{1-\tau}{\tau}\left(\frac{\mu - 2n\alpha}{2n}\right)\right]$$

The equation defining π^D was explained in chapter 4. The equation defining π_d^D assumes the same demand and labor usage as before, and has incorporated the additional transport costs.

In order for it to be profitable to deviate from full centralization we need that $\pi^D > \pi_d^D$. Mathematically:

$$\frac{1}{\beta}\left[\frac{\mu(1-\beta)}{n} - 2\alpha\right] > \frac{1}{\beta}\left[\frac{\mu(1-\beta)}{n} - \alpha - \frac{1-\tau}{\tau}\left(\frac{\mu - 2n\alpha}{2n}\right)\right]$$
$$\alpha < \frac{1-\tau}{\tau}\left(\frac{\mu - 2n\alpha}{2n}\right)$$

$$\Longrightarrow \frac{1-\tau}{\tau} > \frac{2n\alpha}{\mu - 2n\alpha} \qquad (***)$$

B.9 Condition for the Existence of Multiple Equilibria

We use the following condition to show that there must exist an interval of medium transport costs where multiple equilibria are possible at the same time:

$$\frac{2n\alpha}{\mu - 2n\alpha} < \frac{2n\alpha}{\mu(1-\mu)\beta}$$

We can explain why this condition must hold by reformulating it and comparing the components on the left-hand and right-hand side:

$$\mu(1-\mu) < \frac{\mu - 2n\alpha}{\beta}$$

We use that regional demand from the periphery in the case of centralization is given by $X^C_{Mj} = \frac{\mu(1-\mu)}{2}$, and that total demand in the case of decentralization is given by $X^D_M = \frac{\mu - 2n\alpha}{\beta}$.

The left-hand side of the inequality is equal to twice the regional demand from the periphery in the case of centralization, $2 \times X^C_{Mj}$. This is twice the demand from farmers (without a profit income) in a region, which due to the existence of modern workers must constitute less than half the population (which is normalized to one). The right-hand side of the inequality is equal to the total demand in the case of decentralization, X^D_M. This is the demand from all workers in both regions, some of which may have a profit income. Thus, as long as modern workers exist, the left-hand side is lesser than or equal to $\frac{1}{2}$, and the right-hand side is more than or equal to 1. In other words, as long as modern workers exist (which is the only interesting case to look at), the condition used to identify the existence of multiple equilibria will always hold.

B.10 Why Centralization is the Optimal State

Below follows an analytical explanation of why centralization is the optimal state with regards to utility. For reference, here are the equations for profits per firm in the case of full centralization, Π^C, and in the case of full decentralization, Π^D:

$$\Pi^C = \frac{1}{\beta}\left[\mu(1-\beta) - n\alpha - \beta\frac{\mu(1-\tau)(1-\mu)}{2\tau}\right] \tag{8}$$

$$\Pi^D = \frac{1}{\beta}\left[\mu - 2n\alpha - \beta\mu\right] \tag{12}$$

If $\Pi^C > \Pi^D$, the following must hold:

$$\begin{aligned}
\frac{1}{\beta}\left[\mu(1-\beta) - n\alpha - \beta\frac{\mu(1-\tau)(1-\mu)}{2\tau}\right] &> \frac{1}{\beta}\left[\mu(1-\beta) - 2n\alpha\right] \\
\beta\frac{\mu(1-\tau)(1-\mu)}{2\tau} &< n\alpha \\
\frac{1-\tau}{\tau} &< \frac{2n\alpha}{\mu(1-\mu)\beta}
\end{aligned}$$

The last line is the same as the threshold defining that full centralization is a stable equilibrium, given by (**). This implies that as long as centralization is a possible equilibrium, this is always the optimal state of the economy.

Table 2: Papers used as Inspiration for the Extended Model

	Type	Description
Dixit and Stiglitz (1977)	Model of monopolistic competition and optimum product diversity	Basic framework of monopolistic competition models, later used in models of NEG and the "Big Push" model
Krugman (1991a)	Basic model of NEG	Simple model of NEG, presented verbally in chapter 1 of the monograph *Geography and Trade*
Krugman (1991b)	Basic core-periphery model of NEG	Somewhat more complex model of NEG. Almost identical to the one introduced in the appendix of *Geography and Trade*
Murphy et al. (1989)	Model of industrialization and "Big Push"	Model of "Big Push" industrialization. Important contribution used as a basis in future models of NEG
Venables (1993)	Model of vertically linked industries	Basic framework of input-output linkages
Krugman and Venables (1995)	Model of NEG at the national level, with vertically linked industries	Moving from regional to national level by assuming an immobile modern labor force. New agglomeration force through input-output linkages
Helpman (1995) and Krugman and Elizondo (1996)	Model of NEG with a limited supply of housing/land	New dispersion force: immobile supply of housing/land. Opposite effect of transport costs compared to Krugman (1991b)
Bjorvatn (1999)	Model of NEG with wage premium in the modern sector	Wage premium which generates a room for "Big Push"

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