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# **The (Rail)road to Structural Change: Transportation Costs, Integration and Production Specialization**

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## **I. Introduction**

From Heckscher-Olin to the 3-factor, n-good cones of diversification, structural change is considered an inevitable part of economic development. Similarly, the growing stock of literature seeking to measure the effects of economic integration on growth and welfare – while ambiguous in proving overwhelming gains – often concludes that a relative degree of openness is essential to economic development (Estevadeordal & Taylor, 2008; Bagwhati, 2004; Stiglitz, 2002). Yet, if structural change is essential to growth and trade enhances it, what, then, is the relationship between structural change and trade?

In the structural change literature, it seems to be a foregone conclusion that production factors move. Meanwhile, there is a dearth of research dedicated to quantifying the movement of these factors. To the extent that trade allows goods and services to flow between economies, it seems intuitive that reductions in trade barriers would be a natural catalyst to structural change and, hence, growth. Ventura (1997) shows that international factor-mobility is crucial to over-coming decreasing returns-to-scale, while McMillan and Rodrik (2011) empirically illustrate that the direction of factor movements is essential to sustained economic growth. But what is the catalyst of these factor movements?

The current study explores the role of economic integration in catalyzing structural change. Specifically, it addresses the question of how reductions in transportation costs affect patterns of production specialization over time. Drawing upon the New Economic Geography literature (Krugman, 1991; Krugman & Venables, 1995) and exploiting a natural experiment in the 19<sup>th</sup> century Austro-Hungarian (or ‘Habsburg’) Empire, I develop a structural model to empirically measure the effect of reduced transportation costs – through the introduction of railroads – on the concentration of manufactures production in a regional economy over time (i.e., 1841-1917). The structural estimations are supplemented by a reduced form strategy that attempts to address the inherent simultaneity bias that the structural estimates are incapable of solving.

Section II provides a brief review of the literature on structural change and trade, while section III discusses the Habsburg natural experiment. Section IV presents the theoretical model and section V proposes an empirical strategy. Section VI describes the data and Section VII concludes.

## **II. Previous Discussions of Infrastructure, Integration, and Structural Change**

### *Infrastructure, Integration and the Impact on Economic Outcomes*

There is a growing body of work dedicated to understanding the impact of massive infrastructure developments on economic integration, development, and production patterns (Keller & Shiue, 2008; Donaldson, 2010; Banerjee et al., 2012; Rothenberg, 2012; Storeygard, 2012). Keller and Shiue (2008) explore the effect of tariff reductions versus decreased transportation costs in stimulating trade in the 19<sup>th</sup> century German empire – a context that is geographically and historically quite relevant to the current study – and find that the introduction of railroads had a more significant effect on decreasing price dispersion than reductions in tariffs (Keller and Shiue, 2008). Donaldson's (2010) work on railroads in 19<sup>th</sup> century India is consistent with these findings, and suggests an even wider range of effects of decreased transportation costs through decreased price dispersion, promotion of interregional trade and increased incomes (Donaldson, 2010).

Nonetheless, there is an existing debate over the role that infrastructure plays in economic growth. In a similar fashion to Fogel's (1962) work concerning the effect of the American railroad on economic growth, Banerjee et al. (2012) find that proximity to transportation networks in China have a moderate effect on per capita GDP levels and no effect on per capita GDP growth. In addition, access to transportation infrastructure may increase inequality (Banerjee et al., 2012).

The patterns of inequality are particularly interesting when examined through the relationship between infrastructure improvements and production location decisions. The New Economic Geography (NEG) literature (Krugman 1991; Krugman and Venables, 1995; Fugita and Venables, 1999; Puga, 1999) provides formal models to explain the mechanisms through which reductions in transportation costs may drive regional inequalities (i.e., “core” and “periphery” patterns), namely via wage differentials that affect the location decisions of firms across space. Recently, a series of empirical applications of the traditional NEG framework is now beginning to shed quantitative light on these predictions. Rothenberg (2012) examines road improvements in Indonesia and finds that the resulting reductions in transportation costs are accompanied by a dispersion of manufacturing firms. While he does not test the welfare implications of this phenomenon, there

are clear potential effects, as road improvements affected rural and urban regions differently. Other direct tests of the NEG theory also find support for the relationship between transportation costs and regional inequality (Brakman, 2005; Redding & Venables, 2004); although the emphasis of these studies is typically on modern Western Europe. In addition, many of these empirical studies focus on relatively short periods of time. Therefore, the present study contributes to this growing literature by examining long-run patterns (over 70 years) of massive infrastructure developments and their consequent effects on production patterns, regional specialization, and long-run economic outcomes.

### *Economic Integration and Structural Change*

The underlying argument of the current study is that economic integration is the necessary mechanism through which long-term structural change occurs (via its ability to incentivize the movement of factors). Hence, eliminating barriers to trade (i.e., tariffs, transportation costs and restrictions on the mobility of factors) should catalyze observable patterns in production. To the extent that structural change induces growth, one should find that structural change-inducing reductions in trade barriers should also result in welfare gains. While there are few studies that link trade barriers to structural change directly, a rich body of work exists that examines the effects of trade barrier reductions on economic growth and welfare.

Estevadeordal and Taylor (2008) confront the heated debate surrounding the effects of trade policy on growth with a model-based empirical analysis that examines liberalizing vs. non-liberalizing countries in the wake of the 1990 GATT Uruguay round<sup>1</sup>. Their results indicate that reductions in general tariffs are only weakly correlated with changes in GDP growth. However, reductions in tariffs on imported capital and *intermediate* goods have the most positive effect on GDP growth (Estevadeordal et al., 2007). Amiti and Konings' (2007) work in Indonesia is consistent with this finding. Using Indonesian manufacturing data from 1991 to 2001 the authors find that reducing input tariffs increases overall productivity by approximately twice as much as decreasing output tariffs (Amiti et al., 2007).

These findings suggest that while reductions in tariffs may induce gains from trade, they are most effective when targeted at specific parts of the production process, namely intermediate inputs. But how do tariff reductions fare when compared to other trade barrier reductions, such as

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<sup>1</sup> Note that the authors use a 'treatment' and 'control' framework, where 'treatment' represents countries that liberalized after 1990 and 'control' represents those that had either already liberalized prior to 1990 or did not liberalize at all

decreasing transportation costs? Following Melitz (2003), Balistreri et al. (2011) conduct econometric calibrations of a general equilibrium trade model to analyze the impact of reductions in tariffs and trade costs on welfare. The results indicate that while tariff reductions create welfare gains four times larger than the baseline, declines in fixed trade costs increase welfare by more than twice that of tariff reductions (Balistreri et al., 2011). When the two are combined, the effect on welfare gains is even higher.

The Habsburg case speaks well to this literature, as it will allow me to test between the importance of the administrative reductions in trade barriers versus physical reductions. Habsburg trade liberalization was characterized both by reductions in tariffs via bilateral and multilateral trade agreements, as well as declines in trade costs through the massive construction of railroads. The section, below, provides an overview of this context.

### **III. Motivation – Habsburg Natural Experiment**

A review of the economic history literature reveals that the economic development patterns of the 19<sup>th</sup> century Habsburg Empire provide a relevant natural experiment in which to explore the above perspectives regarding trade and structural change. By the early 19<sup>th</sup> century, The Kingdom of Hungary (Hungary, hereafter) resided under the rule of the Austrian Habsburg Empire, but retained moderate political autonomy, with representation of its own diet in the imperial parliament. While trade had remained virtually free amongst the sub-regions of the Habsburg lands since the introduction of reforms by Maria Theresa in the late 18<sup>th</sup> century, tariffs between Austria and Hungary persisted well into the mid-19<sup>th</sup> century (Komlos, 1983).<sup>2</sup> That is, tariffs within Austrian provinces (e.g., Bohemia, Moravia, Galicia, Tirol, Krakau, etc.) had been virtually eliminated, while tariffs between these places and Hungary endured.

After defeat by the Austrians in the revolutions of 1848, Hungary was fully incorporated into the Austrian Empire, losing all of its administrative power and political representation. Furthermore, because the Austrian Constitution prohibited internal tariffs, the existing tariffs between the two regions were forced to dissolve (Eddie, 1977). Effectively, a customs union between the two formed. 1850 marks the official creation of the customs union, but the years just prior to 1850, until two decades afterward (i.e., roughly, 1848 to 1873), are commonly cited in the literature as a period of political and economic liberalization throughout the Empire (Eddie, 1977; Good, 1975; Komlos, 1983). Internally, these reforms were characterized by the liberation of the

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<sup>2</sup> Many authors claim that a significant motivation for the persistence of tariffs was a result of Austrian strong-arming against Hungarian nobles who refused to pay land taxes. (Eddie, 1977; Komlos, 1983; Good, 1975).

serfs in 1848, the introduction of two joint-stock banks in 1853 and 1857, the establishment of a central bank and common currency, and the abolition of the guild system in 1859 (Eddie, 1967). Externally, the Habsburgs followed the trade liberalization trends of the day, engaging in “liberal treaties” with England, Germany and other economic powers of the region, which limited Austrian specific duties and ad valorem taxes (Eddie, 1977).

With the creation of the Dual Monarchy (i.e., the Austro-Hungarian Empire) in 1867, Hungary regained political autonomy within the Empire, and in fact, this autonomy was much stronger than that of the beginning of the century. Each region maintained its own parliament, but the Dual Monarchy shared a military, as well as joint fiscal and foreign policy. Although external protectionist sentiments began to emerge in this period throughout Austrian and Hungarian politics, it is important to note that the customs union persisted until the collapse of the Empire in 1913 (Eddie, 1977). The years following the creation of the Dual Monarchy are typically cited as the return to external protectionism within the Empire, most notably with the crash of the Vienna stock market in 1873 and reactions to tariff hikes in Germany in the early 1880s (Eddie, 1977). Consequently, the assumption of the present study is that one may consider Austria-Hungary a relatively closed economy in which internal regions underwent permanent trade liberalization. In other words, we can think of the Empire as a world economy with two markets that move from relative autarky to relative openness. This perspective is confirmed to some extent by the economic history literature, which claims that internal tariffs between Austria and Hungary were lower than the external tariffs with the rest of the world (Eddie, 1977; Komlos, 1983). Although external trade did exist, the bulk of Habsburg trade appears to have occurred between Austria and Hungary (Komlos, 1983).

In addition to the trade policy story, a significant feature of the Habsburg development path revolves around the introduction of railroads. 1837 marks the inauguration of the railway era, with the laying of 14 kilometers (km) of track in Austria. By 1870, rail construction began to boom with almost 2,000 km of track laid in that year alone. By the beginning of the 20<sup>th</sup> century, almost 45,000 km of track had been laid in the entire Dual Monarchy. Figures I(a) and I(b) illustrates the path of railroad construction between 1837 and 1914 in Austria and Hungary.

The economic history literature is not able to quantify the exact role railroad construction played in Habsburg economic development. However, numerous authors cite it as a potentially significant driver of growth through its linkages to other industries, namely iron (Eddie, 1977); as a force of economic integration (Good, 1984); and as a solution to inefficient overland routes

between markets that previously lacked access to the Danube (Rosegger, 1996). The goal of the present study is not to identify the railroad's role in driving growth, but rather to examine its position in promoting integration and catalyzing structural change. A preliminary examination of the data reveals that structural change was indeed occurring over the course of the 19<sup>th</sup> century and may be correlated with the rise of the railroads. Figures II - IV illustrate the trends in production structure.

From figures II and III, it appears that in both Hungarian agriculture and Austro-Hungarian manufacturing production trends were fairly flat until around 1870 – the beginning of the railroad boom. Specifically, in Hungarian agriculture, there is no distinction between output of wheat, rye or potatoes, until the late 1870s, in which we observe a stark increase in wheat and potatoes production, with virtually no change in the trend for rye production. While the gains in potato production are likely due to technological improvements in agriculture<sup>3</sup>, it is suspected that the rapid increase in wheat production is largely correlated with the increase in Hungarian flour production in the early 1870s. That is, the boom in flour production observed in the Hungarian data for the early 1870s may have created a demand for wheat inputs, thereby explaining the rapid increase in wheat production we observe in the late 1870s.

An examination of the Austrian data reveals that manufacturing trends were relatively flat between iron, cotton textiles and flour until approximately 1865, when textiles and iron began to emerge as the higher value-added goods. Although the major booms in imperial railroad construction did not occur until 1870, Austria had been undergoing steady construction since the 1840s (as opposed to Hungary, which did not experience any serious construction until 1855). Therefore, it is quite likely that railroad development would have affected the patterns of Austrian structural change as early as 1865. Nonetheless, Figure III reveals that there was a clear divergence away from flour production in favor of more intensive manufactured goods, such as cotton textiles and iron, suggesting strong patterns of structural change in Austria in the last half of the 19<sup>th</sup> century.

Figure IV compares Austrian and Hungarian production, by manufactured good, and suggests evidence for relative specialization between the two regions. Because the figures are presented in gross value-added terms and noting that the Hungarian economy was significantly smaller than the

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<sup>3</sup> The height of the Industrial Revolution in Eastern Europe occurred in the late-19<sup>th</sup> century. During this time, large improvements in agricultural technology were made, including the use of chemical fertilizers, crop rotation and reapers (Good, 1984; Eddie, 1967; Van Zanden, 1991; Bicki, 2001). Potatoes are a soil-intensive crop and would have presumably benefited greatly from these improvements in technology.

Austrian economy, one should pay closer attention to slopes rather than vertical distances between trends when attempting to discern patterns of structural change. With this in mind, some clear patterns emerge: Austria developed a relative specialization in intensive manufactures, such as iron and cotton textiles, while Hungary specialized in lower intensity manufactures, such as flour. In addition, the emergence of these trends appears to be highly correlated with the introduction of railroads, as the trends begin to emerge around 1870.

The Austro-Hungarian narrative provides the motivation for the current study. That is, through the 19<sup>th</sup> century Habsburg economy, it appears that there may be empirical evidence to support the notion that reductions in transportation costs catalyze structural change. Below, I outline the theoretical model I will use to test this hypothesis.

#### **IV. Theoretical Model**

Of particular relevance to the question of the role of transportation costs in shaping the production structure of an economy is the New Economic Geography (NEG) literature. Pioneered by Krugman (1991) – and largely expounded upon by Krugman and Venables (1995), Puga (1999), Helpman (1998) and Hanson (1998, 1999), among others – NEG aims to describe the spatial patterns of production inter-regionally and internationally. While the original models do not necessarily lend themselves to direct empirical tractability, a few recent studies (e.g., Hanson, 1999; Brakman et al., 2002; Brakman et al., 2005) have developed ways to directly test the strong theoretical predictions of the NEG. The current study will aim to follow in these empirical pursuits. But first, let us review the theoretical model.

The present research will draw largely from Krugman and Venables (1995). While modifications have been made to the underlying assumptions of this model (e.g., Puga, 1999; Hanson, 1999), note that many of the final predictions end up relatively close to the original predictions of either Krugman (1991)<sup>4</sup> or Krugman and Venables (1995).

Following Krugman and Venables (1995) and Brakman et al. (2005), assume two regional economies, Austria and Hungary, in which two goods, manufacturing (M) and Agriculture (F), are produced in each region. Note that the model will be discussed in terms of Austria as the home market, since the economic history literature suggests that Austria was the larger market of the two. This is largely due to the fact that the results of the model are derived on the assumption that the home market is the larger market of the regional economy.

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<sup>4</sup> Krugman (1991) is a simplified version of Krugman and Venables (1995) in which there is free mobility of labor and no intermediate inputs into manufacturing.



Agriculture is perfectly competitive, using only labor as an input with constant returns to scale. Agricultural goods are the numeraire, such that their price is normalized to  $Q_F = 1$ , and are traded costlessly.

### Consumers

A representative consumer has a CES utility function, which is maximized subject to a budget constraint:

$$\text{Max } U = F^{1-\gamma} M^\gamma \text{ s.t. } wL = Q_F^{1-\gamma} Q_M^\gamma, \text{ where:} \quad (1)$$

$U$  = utility

$wL$  = wage income,  $Y$

$L$  = labor supplied

$F$  = consumption of agricultural good (numeraire)

$\gamma$  = share of income spent on manufactured goods

$Q_M^A$  = price index of manufactured goods in Austria:

$$Q_M^A = [n_A p_A^{1-\sigma} + n_H (p_H T)^{1-\sigma}]^{1/(1-\sigma)}, \text{ where:} \quad (2)$$

$n_i$  = number of variety of goods sold in Austria (A) or Hungary (H)

$p_i$  = price of a given good sold in Austria (A) or Hungary (H)

$T$  = “iceberg” transport costs, such that  $1/T$  goods actually arrive in Hungary

$M$  = consumption of manufactured goods, which follows a CES aggregated sub-utility function for  $n$  distinct varieties of manufactured goods of the form:

$$M = \left( \sum_{j=1}^n c_j^\rho \right)^{1/\rho}, \text{ where:} \quad (3)$$

$c_i^j$  = consumption of variety  $j$ , in region  $i$

Maximizing utility subject to the budget constraint yields the manufacture-demand function:

$$c_i^j = (p_i^j)^{-\sigma} (Q_M^j)^{1-\sigma} \gamma Y_i, \text{ where:} \quad (4)$$

$\sigma$  = elasticity of substitution,  $\frac{1}{1-\rho}$

$Y_i$  = Total output in region,  $i$

### Producers

Producers are monopolistically competitive and produce a domestically consumed good,  $y$ , as well as an export good,  $x$ . Note that the production process uses a composite intermediate input, as well as labor, to produce this good. Krugman and Venables (1995) make the strong assumption that the intermediate good used in production is also consumed by consumers. This allows  $Q_M$  be the same for the final and intermediate good.

Define producers' total cost function in Austria as:

$$TC = w^{1-\mu} Q_M^A{}^\mu [\alpha + \beta(y + x)] \text{ , where:} \quad (5)$$

$\mu$  = intermediate good's share in production

$\alpha$  = fixed input requirement

$\beta$  = marginal input requirement

$y$  = domestic market good

$x$  = export

Firms maximize profits and derive a Dixit-Stiglitz (1977) price mark-up of the function:

$$p(1 - \frac{1}{\sigma}) = w^{1-\mu} Q_M^A{}^\mu \beta \quad (6)$$

The profit maximization with free entry and exit yields the zero-profit condition:

$$\pi = \frac{w^{1-\mu} Q_M^A{}^\mu \beta}{(1 - \frac{1}{\sigma})} (y + x) - w^{1-\mu} Q_M^A{}^\mu [\alpha + \beta(y + x)] = 0 \quad (7)$$

which establishes the unique size of firm:

$$(y + x) = \frac{(\sigma - 1)\alpha}{\beta} \quad (8)$$

### *Equilibrium*

Krugman and Venables (1995) assume that producers have the same elasticity of substitution as consumers, which allows us to use the same CES aggregator function for manufactured goods. Therefore, demand for the manufactured good of variety  $j$  in the home region becomes:

$$c_j = p_j^{-\sigma} Q_M^{1-\sigma} \gamma E, \quad E = \gamma wL + \mu(y + x)pn \quad (9)$$

$\gamma wL$  = consumers' expenditures on manufacturing

$\mu(y + x)$  = demand for intermediates

Assuming for the moment that  $y$  is consumed in Austria, while  $x$  is consumed in Hungary, allows us to define:

$$M = \sum_{j=1}^n c_j = (y + x) \Rightarrow (y + x) = p^{-\sigma} Q_M^{A 1-\sigma} E^A + p^{-\sigma} T^{1-\sigma} Q_M^{H 1-\sigma} E^H \quad (10)$$

Note that transportation costs are applied only to  $x$ , the good exported to Hungary, since under iceberg transport costs, only a fraction of good  $x$  will arrive. Substituting (8) into the left hand side of (10) and using the price mark-up condition from (6) allows us to find the equilibrium wage condition:

$$w_A = k Q_M^{A \frac{-\mu}{1-\mu}} (E^A Q_M^{A \sigma-1} + E^H T^{1-\sigma} Q_M^{H \sigma-1})^{\frac{1}{\sigma(1-\mu)}} \quad (11)$$

It is the wage equation (11) that drives the main theoretical predictions of the model. Figure V presents the predicted relationship between transportation costs and wages. The primary intuition behind the predictions is the following: when a portion of manufacturing inputs is from intermediates (i.e.,  $\mu > 0$ ) and transportation costs are high, the cost of relocating production is too prohibitive such that each region produces both manufacturing and agricultural goods in relative states of autarky. With similar endowments and marginal productivities of labor, initial wages will be relatively equal in each region.

Next, consider a gradual reduction in transportation costs to a critical threshold<sup>5</sup>. Once the critical level is reached, the cost of relocating production is cheaper, thus making intermediates more mobile. The larger market (i.e., the larger the  $E$ ; in this case, Austria) will have a greater demand for intermediates, such that the production of these goods moves out of the smaller market (i.e., Hungary) and closer to the production of final goods in the larger market. With the increase of intermediates, the production of manufactured goods in the larger market will begin to rapidly increase, thus raising the demand for labor in Austria. Alternatively, the decreased production of manufactured goods in Hungary decreases the demand for labor in this region. Consequently, wages will respond to the demand for labor such that wages in Austria increase and wages in Hungary decrease in a diverging fashion.

Finally, once transportation costs approach unity, the importance of locating intermediates near the production of final goods becomes less important, since they may be shipped at relatively low cost. Therefore, manufacturers will take advantage of the lower wages in Hungary and relocate their production processes to the smaller market. The increased demand for labor in Hungary will increase the local wage (and vice versa for Austria) such that we observe a re-convergence in wages across the two regions.

The stylized data in figures II-IV seem to suggest a trend in Austro-Hungarian production patterns similar to the theoretical predictions, above. It is, therefore, the goal of the current study to exploit the wage equation in a reduced-form to estimate the pattern of 19<sup>th</sup> century structural change in the Habsburg Empire. Section V discusses the empirical strategy of the structural model and highlights some important identification issues that will need to be addressed when implementing this model empirically.

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<sup>5</sup> For the mathematical identity of the critical level, see Krugman & Venables (1995) and Puga (1999).

## V. Empirical Strategy

Equation (11) lends itself nicely to a structural empirical model with a reduced-form estimation strategy. To observe this, note that taking the log of (11) yields:

$$\log(w_A) = k + \frac{\mu}{1-\mu} \log(Q_M^A) + \frac{1}{\sigma(1-\mu)} \log \left[ E^A Q_M^A{}^{\sigma-1} + E^H T^{1-\sigma} (Q_M^H)^{\sigma-1} \right] \quad (12)$$

Equation (12) may then be specified as linear regression equation of the following form:

$$\log(w_A) = \beta_0 + \beta_1 \log(Q_M^A) + \beta_2 \log \left[ E^A Q_M^A{}^{\sigma-1} + E^H T^{1-\sigma} (Q_M^H)^{\sigma-1} \right] + \varepsilon \quad (13)$$

That is, by estimating  $\beta_1$  and  $\beta_2$  from (13) we are able to solve for the parameters of the wage equation (11). Once these parameters are estimated, we can plug them back into (11), along with the observable independent variables, to map the wage patterns of Austria and Hungary over various levels of transportation costs (i.e., similar to the theoretical trends predicted by Krugman & Venables (1995) and Puga (1999) in Figure V).

While the Habsburg case is largely motivated by the differences between Austria and Hungary, it is also possible that regional differences emerged within the various provinces and / or districts of the two major regions. Therefore, we may expand the two-region case to a multi-region framework. The structural model thus becomes:

$$w_i = c Q_i^{\frac{-\mu}{1-\mu}} \left[ \sum_j Y_j Q_j^{\sigma-1} T_{ij}^{1-\sigma} \right] \quad (12a)$$

$$SA_i = \sum_j n_j (p_j T_{ij})^{1-\sigma} \Rightarrow Q_i^{\frac{-\mu}{1-\mu}} = \left[ (SA_i)^{1/\sigma} \right]^{-\mu/(1-\mu)}$$

$$MA_i = \left[ \sum_j Y_j Q_j^{\sigma-1} T_{ij}^{1-\sigma} \right]$$

$$\ln(w_{it}) = \alpha_0 + \beta_1 SA_{it} + \beta_2 MA_{it} + \eta_i + \mu_t + \varepsilon_{it} \quad (13a)$$

where, in the NEG literature,  $SA$  is “supplier access” and “ $MA$ ” is market access (Redding & Venables, 2004). These two concepts are fundamental to empirical estimation of NEG models. Market access is the “access” that consumers have to goods in the “foreign” market, while supplier access is the “access” that producers in the home region have to inputs from suppliers in the foreign market. Theoretically, one should be able to obtain these measures from the data. However, there are a couple of econometric issues that must be addressed in doing so.

### 1. *Simultaneity Bias of the Wage Equation – A Reduced Form Strategy*

Equations (13) and (13a) rely on price indices  $Q$  in the home and foreign markets. However, note from equation (2) that  $Q$  is a function of prices,  $p$ , which are a function of wages. We cannot, therefore, cleanly estimate the wage equations without addressing this endogeneity. While previous NEG empirical studies have addressed the issue by estimating  $SA$  and  $MA$  from the data, and plugging their predicted values back into the wage equation, simplifying assumptions are often needed (Brakman et al., 2005; Redding and Venables, 2004). For instance, Brakman et al. (2005) estimate  $SA$  and  $MA$  using existing prices and wages data, but make the assumption that  $\mu=0$  (i.e., there is no role of intermediates in the model).

While this method holds precedence, it is still not an entirely clean specification, since wages will continue to be correlated with the error term in equation (13a). Therefore, in this paper I proceed with the empirical NEG precedence, but in order to provide support for the structural findings, I supplement the analysis with the following reduced form strategy:

$$A_{it} = \beta_o + \beta_1 MA_{it} + \sigma_i + \mu_t + \varepsilon_{it} \quad (14)$$

$$MA_{it} = \sum_i \frac{Y_{it}}{T_{ijt}} \quad (15)$$

where,  $A$  represents various measures of specialization, such as:

$$l_{it} = \frac{y_{it}^k}{\sum_i y_{ii}^k} = \begin{array}{l} \text{"localization"} - \text{the share of region } i\text{'s production of a particular good} \\ \text{ / industry as a proportion of the total output of that good / industry} \\ \text{within the Empire.} \end{array}$$

$$|w_i - w_j| = \text{wage differentials}$$

$$n_{it} - n_{it-1} = \text{entry of new firms}$$

and  $\sigma_i$  and  $\mu_t$  represent region and time fixed effects, respectively.

Note here that the market access term is similar to that of the structural model; however it has been simplified to represent the sum of GDP across regions, divided by the transport costs between region  $i$  and region  $j$ . One can see from (15) that market access is a decreasing function of transportation costs.

### 2. *Modeling Transportation Costs*

As it relates to the Habsburg experiment, transportation costs are represented by the construction of railroads across time and space. The theoretical model predicts that as

transportation costs decrease, production specialization patterns will develop across regions, such that industrial production is concentrated in one (set of) region(s) over another. The Habsburg natural experiment suggests that as railroads were constructed in various regions of the Empire and at differing times, transportation costs should decrease such that certain regions become specialized in industrial production, while others remain relatively more agrarian.

Specifically, the  $T_{ijt}$  term in equation (15) is calculated as the reciprocal of the density of track in region  $i$  in year  $t$ , times the Euclidean distance between the centroids of region  $i$  and region  $j$ . As the density of track increases in region  $i$  over time, the transportation cost term will decrease, such that market access increases. The resulting increase in market access should increase localization, wage differentials, and the entry of new firms.

### 3. *Endogenous Placement of Railroads*

A major issue with any study of massive infrastructure developments is that the placement of such projects is likely endogenously correlated with economic outcomes. That is, it seems intuitive that the Habsburgs would have elected to construct railroads in places that were experiencing industrial growth in order to move intermediates and final goods in and out of these regions more efficiently. Similarly, as railroads reached these places, industrial specialization would be catalyzed via the mechanisms outlined in the theoretical model, above. It will, therefore, be necessary to construct a proper counterfactual for the placement of these tracks. Donaldson (2008) addresses this issue in India by running a placebo estimation in areas that were earmarked for railroad construction, but never saw the plans of construction come into fruition. In the current study, I can run a similar placebo test using a set of railroad plans from 1864, which I overlay with a railroad map from 1910 in order to determine which lines from the 1864 plans were never built. I then include a variable in equation (15) that is the density of *unbuilt* tracks in region  $i$ . If unobservable determinants of  $A_{it}$  (industrial specialization) decided the placement of railroads, then we would expect to see correlation between the unbuilt lines variable and  $A$ , when controlling for province fixed effects. However, if the decline in transportation costs associated with railroad construction is truly the one-way driver of production specialization, then we would expect the coefficient on the unbuilt track variable to be statistically insignificant.

While the placebo approach is appealing, it cannot completely refute the endogeneity bias. Therefore, as a further robustness check, I also implement three different instrumental variables approaches.

There is little narrative (in English) on the motivations for railroad placement in the Habsburg Empire. Rosegger's (1996) essay – while providing data solely for 19<sup>th</sup> century Transylvanian railroads – claim to represent an accurate narrative of the nature of railroad construction throughout the Empire (Rosegger, 1996). In his account, placement of rail lines was characterized by tensions between local versus Imperial interests. While the Empire desired to place lines that would result in better access to maritime waterways (e.g., Black Sea), local interests were often concerned with the density of tracks, rather than destinations (Rosegger, 1996). Eddie (1967) references the Austrian historian, Karl Bachinger, who claimed that railroad placement was motivated largely in the early stages by military strategies, as the seeds for the 1848 revolutions began to grow, and the desire to avoid linking regions with underlying separatist sentiments and ethnic conflict in the latter part of the century (i.e., post 1880) (Eddie, 1967). Consequently, the economic history literature seems to suggest that the motivations for railroad placement were not entirely economically motivated. This notion lends itself to a couple potential instruments: 1) percent of military population in region,  $i$ , at year  $t$ ; or 2) percent of ethnic fractionalization in region,  $i$ , at year  $t$ . The first-stage regressions, therefore, are identified as:

$$Track_{it} = \beta_0 + \beta_1 \%Military_{it} + \gamma X + \sigma_i + \mu_t + \varepsilon_{it} \quad (16)$$

$$Track_{it} = \beta_0 + \beta_1 EthnicFract_{it} + \gamma X + \sigma_i + \mu_t + \varepsilon_{it} \quad (17)$$

where,  $\%Military$  and  $EthnicFract$  are the percentage of military population and ethnic fractionalization measures mentioned, above, and  $X$  is a vector of controls. This estimated  $Track$  variable will then be plugged back into the  $T_{ijt}$  term in the denominator of the market access variable.

However, one may argue in the case of military population that governments only place military presence in regions that are economically significant, thereby violating the exclusion restriction for military population as a good instrument for track density. Therefore, I implement an alternative set of instruments that exploit spatial and temporal determinants of railroad construction.

The Habsburg trade statistics show that in the middle periods (i.e., 1860s) of railroad construction, the Empire imported a significant number of railroad tracks. While the data does not provide the country of origin, other data relating to bilateral trade with Germany reveals a large trade deficit (i.e., an excess of imports) with Germany in regard to 'fuels and construction materials'. Meanwhile, the consensus in the historical literature seems to be that Germany financed

a large portion of the construction of the lines. It would, therefore, seem that railroad construction decisions were spatially dependent on proximity to Germany.

In addition, according to historical documents, the demand for coal was a particular motivator for railroad construction (Entwurf, 1864). Coal was not only a necessary input into railroads, as it powered locomotives, it was also vital to industrial production. The historical argument claims that the relationship between coal mining, iron production and railroad development was so intertwined that the development of the railroad was in part responsible for the dearth of coal in Austria, as it required large amounts of coal to operate, and at the same time, constituted a means through which this dearth of coal could be ameliorated, should the construction of a more comprehensive railroad network be achieved. Therefore, it would seem that railroad construction decisions were temporally dependent on world coal prices. It is important to note that while world coal prices may affect industrial production, they should only have an effect on levels. That is, assuming that the production function for industrial goods is the same across regions, an exogenous fluctuation in the world price of coal would affect production functions equally across regions. This should have no consequent effect on regional industrial specialization. Instead specialization patterns should remain static and only levels of production should be affected.

Therefore, a proposed instrument is to interact distance from Munich – the closest German industrial center to the Austro-Hungarian Empire – with world coal prices to instrument for track density. The first stage regression takes the following form:

$$Track_{it} = \beta_0 + \beta_1 DistGER_i + \beta_2 PriceCoal_t + \beta_3 DistGER_i * PriceCoal_t + \gamma X + \sigma_i + \mu_t + \varepsilon_{ijt} \quad (18)$$

Finally, in the infrastructure literature, it is commonplace to augment the market access term using lagged values for population, total output, or both (Keller and Shiue, 2008; Rothenberg, 2012), in order to instrument for infrastructure development. Therefore, in order to make my findings comparable across the literature, I implement a third first-stage regression of the following form:

$$Track_{it} = population_{i1800} + \sum_i \frac{Y_{i1800}}{d_{ij}} \quad (19)$$

where,  $d_{ij}$  is the geographic distance between the centroids of two provinces. This adaptation most closely resembles Keller and Shiue (2008).



#### 4. Temporal Confounding Factors

19<sup>th</sup> century Europe is often characterized by two historical economic phenomena: 1) the Industrial Revolution, and 2) the ‘First Wave of Globalization’. Imaginably, both economic events could affect specialization patterns, thereby driving the stylized data presented in figures II-IV. Consequently, the empirical strategy of the current paper addresses these confounding factors via time fixed effects, as well as robustness checks on price dispersion.

While the Industrial Revolution began in England in the early 19<sup>th</sup> century, it is well documented that massive technological development did not reach Eastern Europe until the latter part of the century (Van Zanden, 1991). As long as technological improvements developed at the same time and rate between Austria and Hungary<sup>6</sup>, a simple time fixed effect, added to equation (13) – and present in (13a) – should control for the general improvements in technology that may be driving production patterns in the two regions.

Controlling for trends in globalization, however, may prove more difficult. The theoretical model in Section IV hinges upon the assumption that the Habsburg economy remained relatively closed, despite temporary reductions in external tariffs. To test for this, it is sufficient to show that integration occurred amongst the Habsburg provinces over the specified time period. Prior studies that aim to identify integration often focus on proving decreased price dispersion over time (Donaldson, 2008; Keller & Shiue, 2008). In this fashion, the present study tests the hypothesis that the railroads, and not the introduction of the Customs Union in 1850, had the larger effect in decreasing price dispersion between the two regions. A regression discontinuity design would be most appropriate, where a crude price dispersion equation takes the form:

$$p_{aht} = \beta_0 + \beta_1 Track_t + \gamma X + \varepsilon_{aht} \quad (20)$$

where,  $p_{ab}$  represents the difference between prices in Austria and Hungary in year  $t$ ,  $Track_t$  is the kilometers of track in the Empire at time  $t$ , and  $X$  is a vector of controls, such as population. Once price dispersion is estimated, one could then examine the trend before and after 1850. If the coefficient on the railroads variable is significant and there is no break in the predicted levels of price dispersion around 1850, one could then conclude that the railroads were more effective in integrating the two regions than the Customs Union.

However, since there are relatively few observations around the discontinuity, 1850, the regression discontinuity may not be a feasible estimation strategy. Therefore, I run a regression

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<sup>6</sup> The premier economic historians of the Habsburg Empire, David Good and Scott Eddie, seem to operate under the assumption that this is true. See Good (1984) and Eddie (1967).

similar to (14) in which the dependent variable is the difference in prices between region  $i$  and  $j$ , and replace the time fixed effects with a dummy variable for year 1850:

$$|p_{it} - p_{jt}| = \beta_o + \beta_1 MA_{it} + \beta_2 Year_{1850} + \sigma_i + \varepsilon_{it} \quad (21)$$

To illustrate a lack of relative integration with the external global economy, one may consider a regression of the following form:

$$p_{ijt} = \beta_0 + \beta_1 LibTreaty_{ijt} + \gamma X + \varepsilon_{ijt}, \quad \forall j \quad (22)$$

Note, here, that two separate regressions would be run for Austria and Hungary, where,  $p_{ijt}$  represents the difference in prices between Austria/Hungary and another European economy,  $j \in (1, \dots, n)$  (e.g., Britain, France, Germany, etc.),  $LibTreaty_{ijt}$  is a dummy for whether or not a liberalization treaty was signed between the two governments in year  $t$ , and  $X$  is a vector of controls, such as population. If the coefficient,  $\beta_1$ , is significant in (21) and *insignificant* in (21) for both the Austria and Hungary regressions, this would substantiate the claim that Austria-Hungary remained a relatively closed economy amidst the First Wave of Globalization, while simultaneously integrating within.

## V. Data Sources

To the great fortune of those seeking to study the Austro-Hungarian Empire, the Habsburgs were very thorough data gatherers. In particular, statistical yearbooks from 1841 to 1917<sup>7</sup> exist for both Austria and Hungary. While there is district-level disaggregation for some years, the majority of the statistics are at the provincial level. Therefore, the subsequent analyses consist of roughly 17 provinces over 65 years, for a total of approximately 1,000 observations per given analysis.

While the statistical yearbooks provide a vast source of data, it is important to note that, to date, none of this data has been digitized. At best, data exists in scanned pdf versions of the 19<sup>th</sup> century books; and at worst, they are stored in volumes of microfiche. Currently, I am in the process digitizing the yearbooks into a comprehensive electronic database. Consequently, the current draft does not provide empirical output. Note, however, that data entry is scheduled to be completed within the month, and empirical analyses are soon to follow.

In addition to the variables described in the empirical strategy of Section V, the yearbooks also contain vast data concerning agricultural production, population growth, infant mortality, primary

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<sup>7</sup> The particular books I plan to use are: *Tafeln zur Statistik der osterreichischen Monarchie* (1842-1871), *Osterreichisches statistisches Handbuch fur die im Reichsrathe vertretenen Konigreiche und Lander* (1882-1917), *Ungarische Statistische Mitteilungen* (1872-1910), and *Ungarisches Statistisches Jahrbuch* (1893-1913).

school enrollment, as well as infrastructure developments and mining, and industrial output. Preliminary examinations of the data that has been entered (1864-1869) reveal some interesting trends in regard to prices and wages. Figure VI of the appendix indicates that there is indeed a wage gap between the “core” manufactures produces (i.e., Upper and Lower Austria, Salzburg, and Bohemia) and the peripheral provinces of Galicia and Bukovina. Similarly, there are noticeable gaps in the nominal prices of staples such as wheat and rye. As more data is entered, and the empirical analysis is conducted, it will be fascinating to see how these trends evolve.

To define transportation costs, the sequencing of railroad construction will be gathered from railroad statistical yearbooks, as well as railroad maps. Provincial data on kilometers of existing track in a given year are available from 1837-1913. In addition, railroad maps from ~1840, ~1870, ~1890, and ~1910 will supplement the provincial level data and provide spatial orientation of connections between provinces.

Finally, in order to specify the confounding factors equation (22) I have data on civilian and military population, ethnic demographics, the timing of trade treaties, and average prices in other 19<sup>th</sup> century European economies. The population and demographic data is available in the statistical yearbooks, while chronicles of trade treaties are available in the economic history literature (see Eddie, 1977). For world prices, the economic historian, David Jacks, provides extensive historical price data for Europe on his website (Jacks, 2011). It appears that at the very least, wheat or grains data is available for ~1800-1914 for Austria-Hungary, with overlapping timelines for Britain (1845-1934), Germany (1800-1887), France (1825-1913), and Belgium (1800-1890).

## **VII. Conclusion**

The relationship between trade and structural change is one that is rarely identified empirically. In an era already characterized by a global commitment to low tariff barriers, the currently-relevant lens through which to view trade liberalization is the reduction of transportation costs, as we continue to observe drastic improvements in transportation technology. The New Economic Geography (NEG) provides a useful theoretical platform from which to identify the role of decreased transportation costs in catalyzing structural change, with its focus on the relationship between transport costs and production location decisions.

The economic history literature, as well as a set of stylized data, suggests that structural change occurred throughout the Habsburg Empire over the course of the 19<sup>th</sup> century, as Austria concentrated production in manufactures and Hungary lagged to catch up until the latter part of

the century. Amidst the First Wave of Globalization, the Industrial Revolution, and drastic improvements in transportation technology, it will be empirically difficult to isolate causal drivers of these observed patterns. The current study proposes a theoretical and empirical strategy to cleanly identify the role of railroad construction (and the consequent reductions transportation costs) in explaining the patterns of production structure in the 19<sup>th</sup> century Habsburg data. First, the empirical methods will explore trends in price dispersion to show that economic integration was deeper between Austria and Hungary than with the outside world. Then, using a time-trend or time-fixed-effects to control for general technological improvements of the Industrial Revolution, the econometric strategy will use a structural model, modified from a Krugman & Venables (1995) NEG model, to show that decreased transportation costs associated with massive railroad construction is the primary factor driving the observed patterns of structural change throughout the 19<sup>th</sup> century Habsburg Empire. While identification issues are present, these can be overcome with instrumental variables, placebo tests and robustness checks.

## References

- Abizadeh, Sohrab and Manish Pandey (2009), "Trade Openness, Structural Change and Total Factor Productivity." *International Economic Journal*, 23(4): 545-559.
- Agenor, Pierre-Richard and Joshua Aizenman (1996), "Trade Liberalization and Unemployment." *The Journal of International Trade & Economic Development*, 5(3): 265-286.
- Amiti, Mary and Jozef Konings (2007), "Trade Liberalization, Intermediate Inputs, and Productivity: Evidence from Indonesia." *American Economic Review*, 97(5): 1611-38.
- Bhagwati, Jagdish. *In Defense of Globalization*. Oxford, New York: Oxford University Press, 2004.
- Balistreri, Edward, Russell Hillberry and Thomas Rutherford (2011), "Structural Estimation and Solution of International Trade Models with Heterogeneous Firms." *Journal of International Economics*, 83: 95-108.
- Banerjee, Abhijit, Ester Dufo and Nancy Qian (2012), "On the Road: Access to Transportation Infrastructure and Economic Growth in China", Working Paper.
- Bíčík, Ivan, Leos Jeleček and Vít Štěpánek (2001). "Land-use Changes and Their Social Driving Forces in Czechia in the 19th and 20th Centuries". *Land Use Policy*, 18:65-73.
- Brakman, Steven, Harry Garretsen and Marc Schramm (2002), "New Economic Geography in Germany: Testing the Helpman-Hanson Model", *HWWA Discussion Paper*, No. 172.
- Brakman, Steven, Harry Garretsen, Joeri Gorter, Albert van der Horst and Marc Schramm (2005), "New Economic Geography, Empirics and Regional Policy", CPB Netherlands Bureau for Economic Policy Analysis, No. 56.
- Corden, W.M. and P.J. Neary (1982). "Booming sector and de-industrialization in a small open economy," *Economic Journal*, 92: 825-848.
- Devarajan, S., Lewis, J.D. and Robinson, S. (1993). "External shocks, purchasing power parity and the equilibrium real exchange rate". *World Bank Economic Review*, 7: 45-63.
- Donaldson, Dave (2010), "Railroads and the Raj: Estimating the Impact of Transportation Infrastructure," NBER and CIFAR working paper.
- Eddie, Scott M. (1967). "The Changing Pattern of Landownership in Hungary, 1867-1914." *The Economic History Review*, New Series, 20(2): 293-310
- Eddie, Scott (1977). "The Terms of Trade and Patterns of Hungarian Foreign Trade, 1882-1913". *The Journal of Economic History*, 37(2): 329-358.
- Entwurf eines neuen Eisenbahn-Netztes der oesterreichen Monarchie* [Wien], 1864.
- Estevadeordal, A., and A.M. Taylor (2008). "Is the Washington Consensus dead? Growth, openness, and the great liberalization, 1970s-2000s". NBER Working Paper No. 14264, August.
- Good, David (1984). *The Economic Rise of the Habsburg Empire: 1750-1914*. Berkeley, Los Angeles, London: University of California Press.

- Hanson, G.H. (1999), "Market Potential, Increasing Returns, and Geographic Concentration," mimeo, University of Michigan (revised version of Hanson, 1998).
- Keller, Wolfgang and Carol Shiue (2008), "Tariffs, Trains and Trade: The role of institutions versus Technology in the Expansion of Markets." NBER Working Paper.
- Komlos, John (1983). *The Habsburg Monarchy as a Customs Unions: Economic Development in Austria-Hungary in the Nineteenth Century*. Princeton: Princeton University Press.
- Krugman, Paul and Anthony J. Veneables (1995), "Globalization and the Inequality of Nations," *Quarterly Journal of Economics*, 110(4): 857-880.
- Jacks, David, <http://www.sfu.ca/~djacks/data/prices/prices.html>. Visited 12/20/11.
- Leamer, Edward E. (1987): "Paths of development in the 3-factor, n-good general equilibrium model" *Journal of Political Economy* 95(5), pp.961-999.
- Leamer, Edward E. et al. (1999): "Does natural resource abundance increase Latin American income inequality?" *Journal of Development Economics* 59, pp. 3-42.
- McMillan, M., and D. Rodrik (2011). "Globalization, structural change and productivity growth." NBER Working Papers No. 17143.
- Melitz, M. (2003). "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity" *Econometrica* 71: 1695–1725.
- Osterreichisches statistisches Handbuch fur die im Reichsrathe vertretenen Konigreiche und Lander* (1882-1917), Vienna. (OSH).
- Puga, Diego (1999), "The Rise and Fall of Regional Inequalities", *European Economic Review*, 43: 303-334.
- Redding, Stephen (2002). "Specialization Dynamics", *Journal of International Economics*, 58: 299-334.
- Redding, Stephen (2006). "Factor Endowments and Production in European Regions", *Review of World Economics*, 142(1): 1-32.
- Redding, Stephen and Anthony Venables (2004), "Economic Geography and International Inequality", *Journal of International Economics*, 62:53-82.
- Rosegger, Gerhard and John H. Jensen (1996). "Transylvanian Railways and Access to the Lower Danube, 1856-1914." *East European Quarterly*, 29(4): 427-448.
- Rothenberg, Alexander D. (2011), "Transport Infrastructure and Firm Location Choice in Equilibrium: Evidence from Indonesia's Highways", Job Market Paper.
- Schott, P. (2003). "One size fits all? Heckscher-Ohlin Specialization in Global Production". *American Economic Review* 93 (3): 686-708.
- Statistische nachrichten über die eisenbahnen der Österreichisch-Ungarischen monarchie*. 1893. Vienna. (OSJ).
- Stiglitz, J. *Globalization and its Discontents*. New York: Norton, 2002.

*Tafeln zur Statistik der österreichischen Monarchie* (1842-1871), Vienna. (Tafeln).

*Ungarische Statistische Mitteilungen* (1872-1910), Budapest. (MSE).

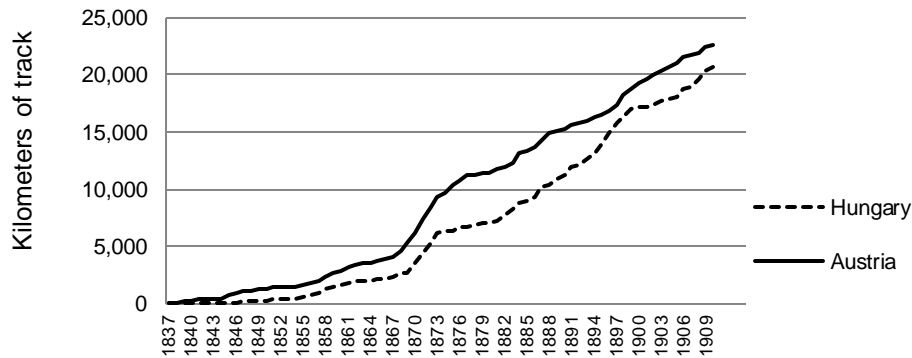
*Ungarisches Statistisches Jahrbuch* (1893-1913), Budapest. (USJ).

Van Zanden, J.L. (1991). "The First Green Revolution: The Growth of Production and Productivity in European Agriculture, 1870-1914." *The Economic History Review*, New Series, 4(2): 215-239.

Ventura, Jaume (1997). "Growth and interdependence." *Quarterly Journal of Economics*, 112(1): 57-84.

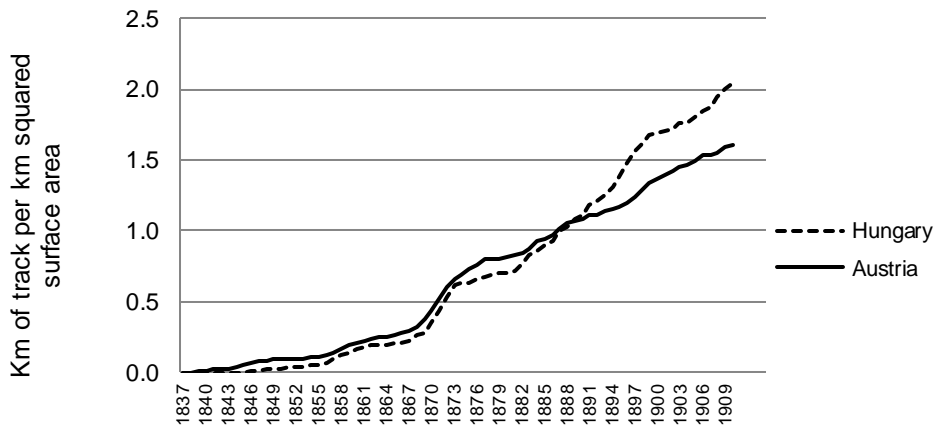
## Appendix

**Figure I(a). Austro-Hungarian Railroad Construction: 1837-1910 – length of track**



Source: Statistische nachrichten über die eisenbahnen der Österreichisch-Ungarischen monarchie;

**Figure I(b). Austro-Hungarian Railroad Construction: 1837-1910 – track density**



Source: Statistische nachrichten über die eisenbahnen der Österreichisch-Ungarischen monarchie;

**Figure II. Changes in Hungarian Production Structure: 1830-1915**

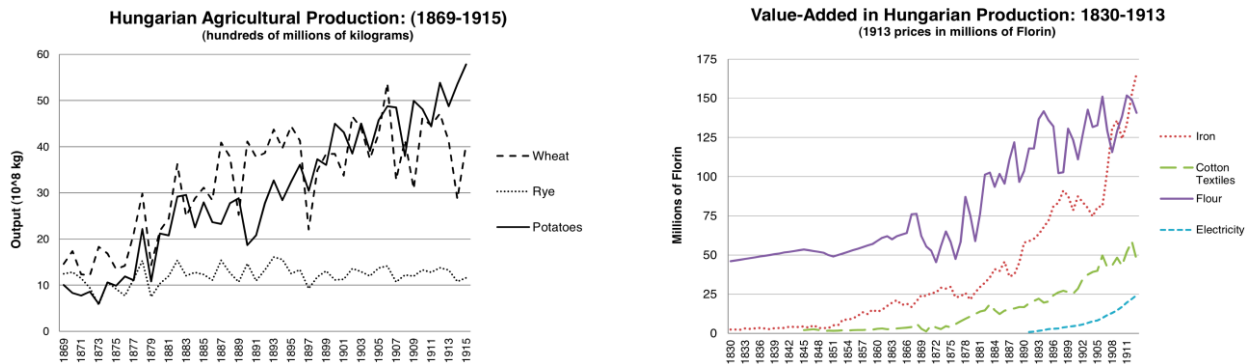




Figure III. Changes in Austrian Production Structure: 1830-1915

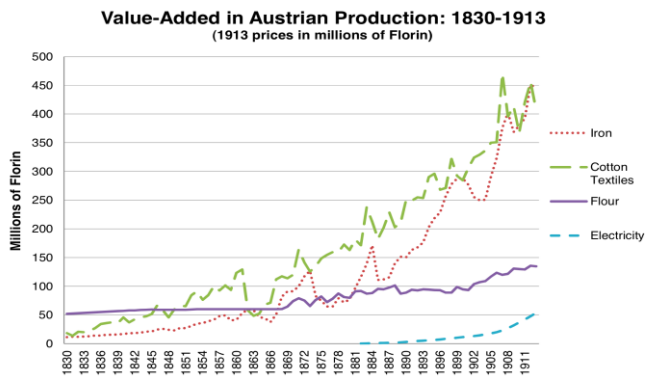
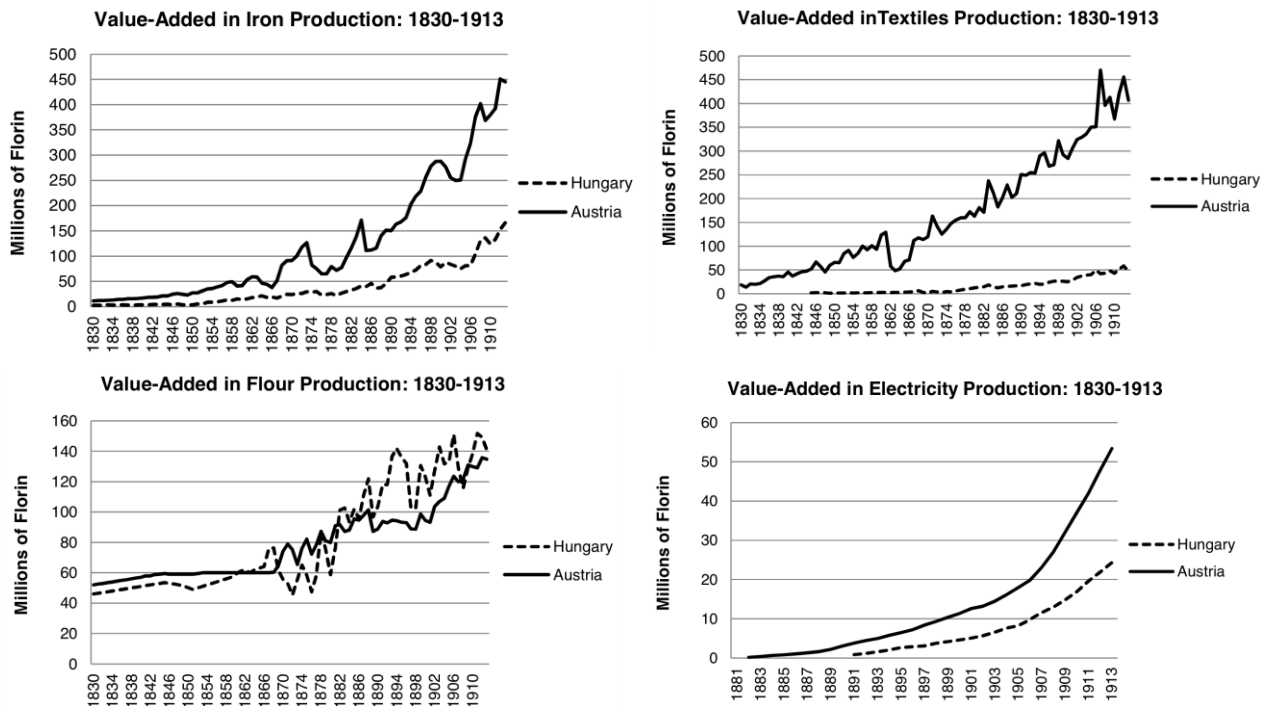
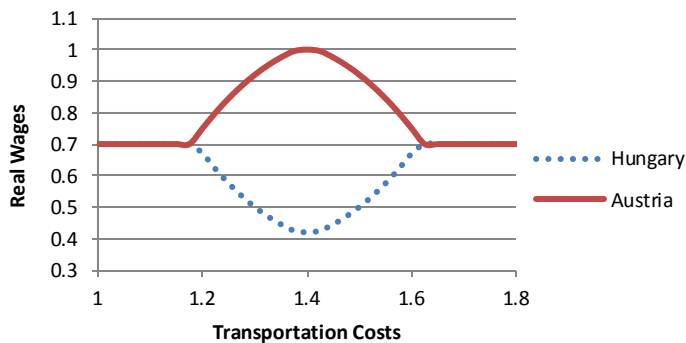


Figure IV. Comparative changes in Austrian & Hungarian Production: 1830-1915



Source (Figures II – IV): Komlos (1983)

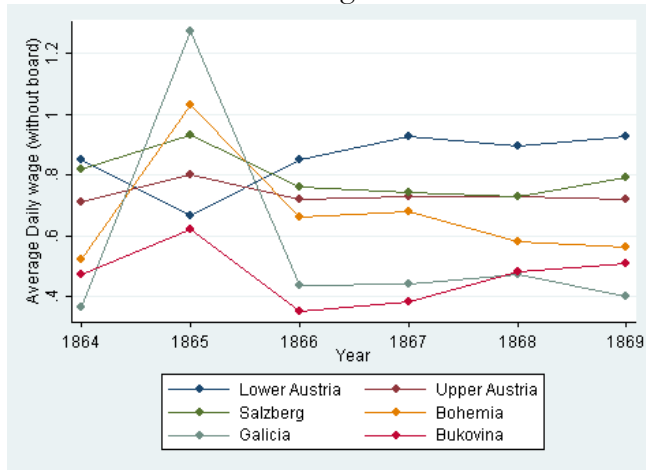
Figure V. Predicted Relationship: Wages and Transportation Costs



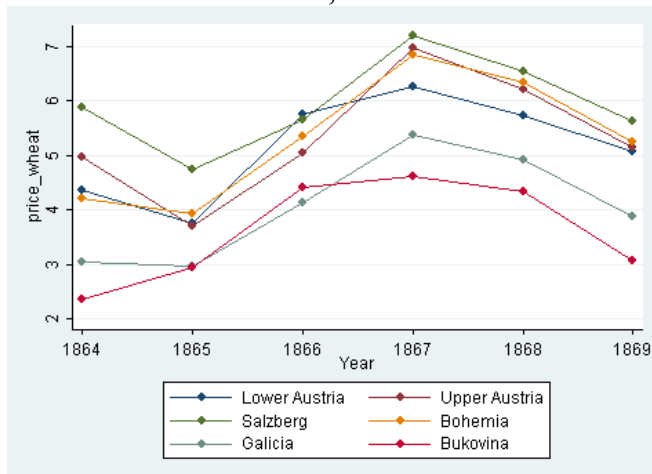
Source: based on the theoretical predictions from Krugman & Venables (1995) and Puga (1999)

**Figure VI. Wages and Prices – preliminary data**

Nominal Wages: 1864-1869



Nominal Prices, Wheat: 1864-1869



Nominal Prices, Rye: 1864-1869

