Can the New Economic Geography explain regional wage disparities in South Africa?

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Abstract

Regional wage disparities are an increasing concern for many developing countries and New Economic Geography (NEG) models offer a theoretical explanation on how such disparities emerge and why they persist. While this theory has largely been tested for developed economies, the present paper aims at providing an empirical validation of the theory for the case of a developing country. The empirical analysis focuses on testing a key prediction of the NEG theory, given by the wage equation, which states that postulates a positive relationship between regional wages and market potential. The paper departs from previous subnational studies in South Africa that have estimated reduced-form models and estimates a structural wage equation based on the Helpman-Hanson model derived directly from the NEG theory. Using non-linear least squares, the cross-section regression analysis covers the period 1996 - 2011. Using 1996, 2001 and 2011 population census data, the results suggest that the prediction of the NEG wage equation holds for the case of South Africa only after controlling for regional specific factors. The results highlight that while the Helpman-Hanson model is appropriate for explaining regional wage disparities in South Africa, other regional specific factors also matter. The analysis shows that the observed regional wage disparities are better explained by the combination of market potential driven by increasing returns to scale, transport costs and love of variety, together with human capital, mineral resource endowments, local climatic conditions, local unemployment rate and homeland status. Overall, the results of this study suggest that the NEG theory is not a direct extension toward explaining regional wage disparities in South Africa and its proper application hinges on the incorporation of other regional structural factors unique to emerging economies.

Keywords: Economic geography; Market potential; Increasing returns; Transport costs.
JEL Codes: F12, R12, R32

1. Introduction

Regional wages vary significantly in both developed and developing economies and they show a strong core-periphery economic structure. The New Economic Geography (hereafter, NEG) theory pioneered by Krugman (1991) provides a theoretical explanation of how and why such

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disparities and economic structure exist and persist over time. The NEG theory emphasises the importance of access to markets in the determination of a region's wage rate. It predicts that greater access to markets lead to higher local wage rate. A famous representation of this prediction set out in Fujita, Krugman, & Venables (1999), is a *"wage equation"*, that posits a positive relationship between regional wages and market potential, an index measuring accessibility to markets (Head & Mayer, 2004).

An extensive body of research has been devoted to empirically test the validity of the wage equation in various countries such as United States (Hanson, 2005; Fallah, Partridge, & Olfert, 2011), Italy (Mion, 2004), Germany (Brakman, Garretsen, & Schramm, 2004; Kosfeld & Eckey, 2010), Brazil (Fally, Paillacar, & Terra, 2010), China (Hering & Poncet, 2009, 2010), Indonesia (Amiti & Cameron, 2007) and Chile (Paredes, 2015). While this research covers, both developed and developing economies, research testing the wage equation remains highly limited in the context of African economies[3]. However, the peculiar economies of most African countries, where income and wage inequalities are highly conditioned on natural resource exploitation, historical institutional settings and peculiar labour market conditions might open new lines of research in this area. The main objective of this paper is to test the validity of the wage equation for the case of South Africa, a unique African country with one of the highest level of inequalities in the world.

The study of regional wage disparities and the empirical validation of the wage equation in South Africa is motivated by several interesting facts. Firstly, South Africa is well-known for having inequalities that are among the highest in the world at both individual and regional levels. A Gini index of 0.66 for income and 0.47 for wages between 2008 and 2012, according to Finn & Leibbrandt (2013), gives an idea of overall inequalities in South Africa. At the regional level, economic activities are highly concentrated in a few places and are entirely or partly non-existent in others (Naudé, Krugell, & Serumaga-Zake, 2002; Naudé & Krugell, 2005; Naudé & Matthee, 2007)[4]. These high levels of concentration point to an economy characterised by significant regional economic disparities. While the high levels of inequalities are of concern to policy makers, existing evidence in South Africa suggests that inequalities at

[3] The most notable exception to estimate a theory-based wage equation across a group of African countries is the work by Bosker & Garretsen (2012). Using GDP per worker to proxy wages, Bosker & Garretsen (2012) finds evidence in support of the wage equation.

[4] 70 percent of the country's GDP is concentrated in 20 percent of the country's regions (Naude and Krugell, 2005), 80 percent of manufacturing in six urban metropolitan areas (Naude, Krugell & Serumaga-Zake, 2002), and 84 percent of manufacturing exports in 6 percent of its regions (Naudé and Matthee, 2007).

both individual and regional level are on the increase in more recent years (Leibbrandt, Finn, & Woolard, 2012; Wittenberg, 2016, 2017; Krugell, Koekemoer, & Allison, 2005; Bosker & Krugell, 2008). The increase in income inequality in post-Apartheid South Africa has been attributed to large and increasing dispersions in labour market earnings (Ntuli & Kwenda, 2014; Wittenberg, 2016, 2017). A detailed analysis of the causes of differences in labour market earnings is therefore crucial in the design of policy measures aimed at promoting equality in the labour market.

Secondly, South Africa appears to have a high degree of regional wage disparities which seem to contribute to the high and increasing levels of overall wage and income inequality, which is a fundamental problem in the country. However, to the best of our knowledge and at the inception of this thesis, the analysis of regional wage disparities has rarely been the main subject of research in South Africa. The bulk of existing research has focused mainly on overall income(Leibbrandt, Poswell, Naidoo, Welch, & Woolard, 2005; Murray Leibbrandt, Finn, & Woolard, 2012) and wage (Burger & Yu, 2007; Wittenberg & Pirouz, 2013;Ntuli & Kwenda, 2014; Burger, 2015; Martin Wittenberg, 2014a, 2014b, 2016, 2017) inequality. At the regional level, a few exceptional studies which focus on regional wage disparities include Kingdon & Knight (2006), Magruder (2012) and von Fintel, (2016)[5]. Thirdly, few studies have used the NEG theory to explain regional disparities in GDP per capita (Naudé & Krugell, 2003, 2005, 2006; Naudé, Krugell, & Matthee, 2010), output per worker (Krugell & Rankin, 2012), manufacturing (Fedderke & Wollnik, 2007) and export performance (Gries & Naude, 2008; Matthee & Naudé, 2008; Naudé & Gries, 2009). While this research has shown that market potential matters, the evidence is based on the estimation of reduced-form equations that do not show clearly the precise mechanisms through which market potential operates. The limited research on regional wage disparities provides substantial scope for further research in this area in the case of South Africa.

Finally, while the NEG theory explains regional wage disparities based on very narrow economic forces generated by the interplay of the manufacturing and transport sectors, these

[5] Magruder (2012) used magisterial districts as the unit of analysis to examine the effects of bargaining council on various labour market outcomes (employment, employment by firm size and wages by industry), while Kingdon and Knight (2006), as well as von Fintel (2016) used individual workers identified by their location (360 clusters, magisterial districts, districts councils and provinces) as the unit of analysis to examine the effects of local unemployment rate on individual wage.

sectors are relatively less developed in South Africa compared to developed countries where the theory has largely been tested. In contrast, like many other emerging economies, South Africa has a strong and robust primary sector highly dependent on natural resources (minerals, agricultural land, access to waterways and favourable climate). This factor is neglected by the NEG theory. However, natural resources, together with historical institutional settings and peculiar labour market conditions might be key determinants of regional wage levels in South Africa and many other emerging countries. The possible tension between these factors on one hand, and the interplay of love of variety, increasing returns to scale and transport costs, on the other hand, provides a unique testing ground of the validity and robustness of the NEG theory as a good theory for explaining regional wage disparities in emerging economies.

Given these issues, a key empirical question addressed in this paper is whether the prediction of the NEG wage equation is consistent with the observed regional wage disparities in South Africa, a country where regional wage disparities seem to be driven by several factors. To address this question, the study estimates a structural wage equation for the years 1996, 2001 and 2011 based on the Helpman-Hanson model which derives directly from the NEG theory. Apart from showing the relationship between regional wages and market potential, estimating the Helpman-Hanson model is empirically appealing as the estimated structural wage equation allows us to unpack the precise channels through which market potential drives regional wage disparities. It also allows us to check the consistency of the estimated results with the underlying theoretical framework, as well as related studies from other countries.

The study contributes to the empirical literature on regional wage disparities in several ways. First, it provides an empirical validation of the NEG wage equation in the context of Africa where studies are still limited. Second, it estimates for the first time a structural wage equation for South Africa based on the Helpman-Hanson model. Third and in line with the overall objective of the thesis, the study contributes to a better and deeper understanding of the causes of regional wage disparities in South Africa by augmenting the Helpman-Hanson model with other potential explanatory factors. Finally, the study contributes towards the practical policy debate on regional wage disparities in South Africa. The goal of addressing regional wage disparities and creating a more equitable labour market may benefit from policies that are well-informed in the determinants of regional wage disparities, in particular, the precise mechanisms through which market potential affects regional wage levels.

The remainder of this paper is structured as follows. The next section discusses the Helpman-Hanson theoretical framework which underlines the empirical analysis. Section 5.3 provides a brief review of the related empirical literature. This is followed by section 5.4 that presents the empirical framework. Section 5.5 describes the data. The results of the empirical findings are reported in section 5.6. Lastly, section 5.7 offers conclusions and policy implications.

2. The New Economic Geography (NEG) theory

There are several theoretical models for explaining the causes of regional wage disparities, among them, the human capital theory, the amenity theory, the regional wage curve theory, as well as the NEG theory. While these models are all important, the NEG theory, however, provides a solid theoretical explanation of how and why regional wage disparities exist and persist over time. This explanation is based on micro-foundations of increasing returns to scale, transport costs and love of variety, which together create pecuniary externalities in the location decisions of economic agents (Fujita & Mori, 2005; Fujita & Thisse, 2009).

While the NEG literature consists of several theoretical models[6], in this paper the Helpman (1998) model derived from the well-known core-periphery NEG model by Krugman (1991) is empirically tested. Although the Krugman (1991) and the Helpman (1998) models are similar in most aspects, they differ in their definition of the competitive sector that acts as the dispersion force. In both models, labour mobility in the manufacturing sector acts as the driving force for agglomeration. However, Krugman (1991) uses immobile agricultural labour and Helpman (1998) non-tradeable housing services as the dispersion force.

In using immobile agricultural labour as the dispersion force, Krugman (1991) has generally been criticised for failing to capture some of the spatial characteristics of agglomeration that have been found to be relevant empirically such as prices of non-tradable – housing services (Brakman, Garretsen, & Schramm, 2004). By incorporating housing services, Helpman (1998) model seems to be more suitable as it captures the key localisation factors (congestion costs - higher land prices) affecting location decisions of both firms and consumers. The model is also preferred because of the less extreme nature of its equilibria. While Krugman (1991) predicts complete agglomeration, which is hardly observed, Helpman (1998) allows for partial

[6] Some of these models includes, Krugman (1991), Krugman & Venables (1995), Venables (1996) and Fujita, Krugman, & Venables (1999) For a review of these NEG models, their main features and the NEG empirics see Overman et al. (2001), as well as Head & Mayer (2004).

agglomeration as high prices of non-tradable services push some economic agents away from agglomeration areas. Thus, by allowing some agents to spread out, the model captures closely the spatial characteristics of most economies.

We provide an explanation of the structure of the Helpman (1998) model. Given that the theoretical framework of this model has been derived many times (see Hanson, 1998, 2005; Brakman et al., 2004; Bruyne, 2010; Kiso, 2005; Kosfeld & Eckey, 2010), the discussion focuses on the key dynamics of the model that leads to the Helpman-Hanson model tested in this paper.

2.1. Helpman-Hanson model

The economy is assumed to have R regions where each region has two sectors, each producing one good. All consumers have identical Cobb-Douglas preferences and maximise utility by consuming a homogeneous, non-tradable housing services and a variety of differentiated tradable manufactured goods. In the economy, housing stocks are produced in a perfectly competitive market and the supply is fixed in each region (Hanson, 2005; De Bruyne, 2010). This implies that prices for housing services tend to be high in densely populated areas and low in sparsely populated areas (Kosfeld & Eckey, 2010).

The manufactured good is produced in a monopolistic competitive market by a firm operating under increasing returns to scale using mobile labour as the only factor of production. Manufactured goods are traded across regions at a cost modelled in the form of an "iceberg" transport cost, meaning that only a fraction of the shipped good arrives at the final destination. The manufactured good can be thought of as a composite of differentiated varieties, and the consumption of each variety is determined by its price, as well as the elasticity of substitution of the manufactured varieties (σ).

In deciding where to locate in space, firms and consumers choose locations that maximise profits and utility respectively. Since manufacturing firms are confronted with increasing returns to scale, they prefer to concentrate production in just one region with greater access to markets - "the home market effect" - to minimise on transport costs and benefit from large-scale production (Redding, 2013). On the other hand, because of consumer love of variety and the need to avoid paying higher transportation costs in importing manufactured goods, consumers also favour locating close to regions with greater access to large markets that offer a wide variety of manufactured goods at lower prices - "the price index effect" (Redding, 2010).

The interplay of the market access effect and the price index effect is mutually strengthening and generates agglomeration forces that stimulate firms and consumers to concentrate close to regions with greater access to markets.

However, the resulting concentration of firms and consumers has associated congestion cost as demand for housing increase, leading to an increase in housing prices - "the crowding effect" (Kosfeld & Eckey, 2010). This cost acts as a dispersion force, pushing for the spreading out of economic activity and regional wages to converge. Overall the spatial distribution of economic activity and resulting wage levels depend on the tension between agglomeration and dispersion forces (Masahisa Fujita, 2007), whose strength, in turn, depends on transportation costs (Redding, 2013). When agglomeration forces are stronger than dispersion forces, an optimal economic result is the divergence of economic activity, income and wages across regions as firms and workers concentrate in core locations with greater access to markets.

Under these conditions, the long-run spatial equilibrium of the economy can be summarised by five simultaneous equations related to real wage, housing expenditure, income, price index and nominal wage. The nominal wage equation is central in examining the relationship between market potential and local wage and the most prominent representation of this equation is set out in Fujita, Krugman, & Venables (1999):

$$w_r = \left[\sum_i Y_i T_{ri}^{1-\sigma} {P_{iM}}^{\sigma-1}\right]^{\frac{1}{\sigma}} \tag{1}$$

where w_r is wage rate for region r. Equation (1) is the NEG wage equation and gives the average wage rate that firms in region r are willing to pay their workers. The average wage rate is a function of income in all other regions (Y_i), the price index for manufactured varieties in all regions (P_{iM}), transport costs between region r and i (T_{ri}) and the elasticity of substitution between manufactured varieties (σ) which satisfies $\sigma > 1$. While equation (1) is central in the empirical validation of the NEG wage equation, it cannot be estimated directly since P_{iM} is an implicit price that cannot be observed directly (Kiso, 2005). To arrive at a testable equation, Hanson (1998) utilised two additional equilibrium conditions of the Helpman (1998) model[7]. In particular, Hanson (1998) used the equilibrium condition of the housing market given by:

[7] Another commonly used strategy to eliminate the manufactured price index is provided by Redding and Venables (2004) who used estimated parameters from a gravity trade model based on bilateral trade data to derive a theory-

$$P_{rH}H_r = (1-\mu)Y_r \quad (2)$$

where P_{rH} is the price of housing services in region r. H_r is the fixed housing stocks in region r. Y_r is total income in region r. Equation (2) suggests that in equilibrium, the market value of housing services supplied in region r equals the share of income spent on housing services in the region given by $1-\mu$. μ is the share of income devoted to consumption of manufactured goods.

In addition, Hanson (1998) used the real wage equalisation assumption, where free labour mobility equalises real wages across regions. While nominal wages can vary across regions in the short-run, labour mobility ensures that in the long-run real wages are equalised as manufacturing workers migrate from regions with low-wages towards locations with higher wages to realise higher utility levels. Real wages are equalised across regions by deflating nominal wages by the regional cost-of-living price index that is a function of housing price P_H and manufactured goods price index P_M. When real wages are equalised across regions,

$$\frac{w_r}{P_{rH}^{1-\mu}P_{rM}^{\mu}} = \frac{w_i}{P_{iH}^{1-\mu}P_{iM}^{\mu}} = \omega \quad (3)$$

, workers have no motive to migrate.

Utilising the housing market equilibrium condition (2) and the real wage equalisation condition (3), Hanson (1998) eliminated the unobservable manufacturing goods price index variable in equation (1) to obtain the following testable model:

$$w_r = \left[\sum_i Y_i^{\frac{\sigma(\mu-1)+1}{\mu}} H_i^{\frac{(1-\mu)(\sigma-1)}{\mu}} w_i^{\frac{\sigma-1}{\mu}} T_{ri}^{1-\sigma}\right]^{\frac{1}{\sigma}} \quad (4)$$

where all the other variables and parameters are defined as before. Equation (4) is now generally referred to as the *"Helpman-Hanson model"*. The right-right of the equation now gives a modified market potential index that is a function of income (Y_i), the housing supply (H_i) and wages (w_i) in all other regions and transport costs (T_{ri}) between regions (r and i).

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based market potential function consisting of two indices: the market access and supplier access indices. Apart for the unavailability of trade data at regional level in most countries, this strategy is less appealing for regional analysis given its underlying assumption of labour immobility.

Hanson (1998) captured transport costs with an exponential distance decay function, $T_{ri} = e^{-\tau d_{ir}}$, where d_{ri} is the distance between region r and i. Thus, according to equation (4), average wage rate in region r is higher when market potential is higher, shown by higher income (Y_i), housing stocks (H_i) and wages (w_i) in surrounding regions, as well as low transport costs between trading regions ($e^{-\tau d_{ir}}$). Thus, wages are systematically higher in regions with higher market potential (greater access to markets), and they are lower in regions with lower market potential (low access to markets).

An appealing feature of equation (4) is that it is directly derived from theory, from which the implications of the NEG theory are fully captured by the key structural parameters of the model namely, the elasticity of substitution among manufactured varieties (σ), the transport costs parameter (τ) and the share of income devoted to consumption of manufactured goods (μ) or housing services ($1 - \mu$). These parameters capture the tension between the forces of agglomeration (access to markets) and dispersion (higher housing costs) that are shaping and influencing the location decisions of economic agents, and consequently the distribution of wages across space[8]. Depending on the level of transport costs, the Helpman-Hanson model is said to be valid when agglomeration forces dominate dispersion forces. This happens when σ is low, μ is high and τ is high. The rational is that low σ allows the exploitation of economies of scale gains by concentrating production in few locations; high μ supports a larger concentration of firms in need of high consumer demand; and high τ encourages concentration of firms and consumers in same locations to avoid incurring high transport costs[9]. For agglomeration forces to dominate, the model parameters, need to satisfy the following constraints: $\sigma > 1$, $0 \leq \mu \leq 1$ and $\tau \geq 0$.

In addition, two relations between model parameters should also be satisfied. The first one, the market power condition given by $\sigma/(\sigma - 1)$, a ratio showing the mark-up of prices over marginal costs. When the condition is such that $\sigma/(\sigma - 1)$ >1, it implies that firms in a given region are operating under increasing returns to scale, a feature key in the NEG theory. The

[8] Thus, these parameters reveal the precise channels through which market potential influences the spatial distribution of economic activities and wages across regions.

[9] On the contrary, economic agents tend to disperse in space, leading to regional wage convergence when σ is high, μ is low and τ is low. The rational is that high σ erodes the benefits from economies of scale gained by concentrating production in few locations; low μ, implies higher share of income is being devoted to housing services, which is turn drives economic agents to locations with low housing costs; and low τ implies firms can serves different markets, while consumers can import goods from different markets at relatively low transport costs.

second one, the no black hole condition given by $\sigma(\mu - 1)$, and determines whether the spatial distribution of economic agents and result wages is determined by transport costs or distribution of housing services. The condition holds when, $\sigma(\mu - 1) < 1$ and depending on the level of transportation costs, economic activities will either agglomerate or disperse in space (Mion, 2004). For instance, the interaction of increasing returns to scale at the firm level and consumer love of variety with increasing transport costs leads to more agglomeration of economic agents and widening of regional wages disparities (Helpman, 1998). On the contrary, when the condition does not hold, $\sigma(\mu - 1) > 1$, the spatial distribution of wages is determined only by the distribution of exogenous factor (like housing stocks) endowments of across regions (De Arcangelis & Mion, 2002). Thus, the no-black hole is crucial in the overall validation of the wage equation as failure for it to hold implies that the Helpman-Hanson model is irrelevant for explaining spatial distribution of economic activities and wages across regions (Kiso, 2005).

3. Related empirical literature.

This section focuses explicitly on the empirical literature that tests the wage equation based on the Hanson (1998) approach which led to the Helpman-Hanson model given by equation (4)[10]. Hanson (1998) was the first to empirically test the validity of the Helpman-Hanson model using data from 3075 US counties over the period 1970-80 and 1980-90. In a revised version, Hanson (2005) augmented equation (4) with regional specific characteristics to control for other potential explanations. Measuring regional wages with average annual earnings per worker, Hanson (2005) finds a significantly positive relationship between regional wages and market potential. His results show that the higher the personal income, wages and housing stocks in proximate locations and the lower the transport costs to those locations, the greater the local wage. His results are robust to the inclusion of human capital, demographic composition of working age population, as well as exogenous amenities.

In addition, Hanson (1998) also finds highly significant structural parameters (σ, μ and τ) that are consistent with the underlying Helpman (1998) model. More precisely, he finds estimates of the elasticity of substitution between manufactured goods σ in the range of 4.9 to 7.6

[10] Apart from the NEG empirical literature which tests the wage equation based on the Helpman-Hanson model, another large body of literature has tested the wage equation based on the approach by Redding & Venables (2004). See paper 2 of this thesis for a detailed explanation of these two approaches, and why Hanson (1998) approach is preferred in this paper.

satisfying the restriction that $\sigma > 1$. The mark-up of prices over marginal cost $\sigma/(\sigma$ -1) implied by these values range between 1.15 and 1.26, suggesting that firms are operating under increasing returns to scale and have some degree of monopoly power. Those of the share of income devoted to manufactured goods μ range between 0.91 and 0.98, also in line with the theoretical restriction of $0 \leq \mu \leq 1$, although these values are somewhat very high. The estimates of the transport cost parameter τ fall in the range 1.6 to 3.2 also in line with theoretical condition for $\tau \geq 0$. He further finds that the interplay of the parameters shown by $\sigma(1 - \mu)$ revealed values between 0.084 and 0.653, suggesting that the no black hole condition holds. This implies that transport costs play an important role in the distribution of economic activities and wages across regions in US. Hence, Hanson's (2005) findings provide overwhelming evidence in support of the validity of the wage equation. Thus, the case of US is well-explained by the Helpman-Hanson model[11].

Building on the pioneering work of Hanson (1998; 2005), other researchers went on to test the validity of the wage equation based on the Helpman-Hanson model in many other countries. These include Roos (2001), Brakman et al. (2000; 2004) and Kosfeld & Eckey (2010) for Germany, Bruyne (2010) for Belgium, Mion (2004) for Italy, Cieślik & Rokicki (2016) for Poland and Kiso (2005) for Japan. Amongst these studies, Brakman et al. (2004), extended Helpman-Hanson model by complementing housing stocks with land prices. Second, they also relaxed the real wage equalisation assumption. Kosfeld & Eckey (2010) extended Helpman-Hanson model by complementing housing stocks with manufactured good's price index data, in line with the initial NEG wage equation (2). Furthermore, Kiso (2005) modified Helpman-Hanson model by including intermediate inputs and building stocks. Acknowledging the similarities between Helpman-Hanson model and Krugman model, another group of studies tested the validity of the Krugman model. These include Turgut (2014) for Turkey, Pires (2006) for Spain and Niebuhr (2006) for regions across EU countries.

From these studies, the first point to notice is that the estimated parameters differ across studies, suggesting varying strength of demand linkages in various countries. For instance, Roos (2001)

[11] Even more interesting, Hanson (2005) finds that, the theory-based wage equation based on the Helpman (1998) model has greater explanatory power than the simple ad hoc wage equation based on the Harris (1954) market potential, that do not control for regional variation in housing stocks.

finds estimates of σ, μ and τ 6.2, 0.86 and 0.003 respectively. De Bruyne (2009) finds estimates of σ, μ and τ of 5.5, 0.81 and 0.003 respectively. Mion (2004) finds estimates of σ, μ and τ of 1.92, 0.87 and 0.19 respectively. Brakman et al. (2004) finds estimates of σ, μ and τ ranging between 3.1 to 4.9, 0.54 to 12.48 and -0.001 to 0.01 respectively. Despite these differences, it is important to note that all these studies lead to similar conclusions as they reveal highly significant and theoretically consistent estimates. These studies, thus provide further evidence validating the Helpman-Hanson model in explaining regional wage disparities in different countries, even after controlling for alternative explanations (Kosfeld & Eckey, 2010) and its extension or modification (Brakman et al. 2004; Kiso, 2005).

The studies cited above focus on developed economies. Extension to developing countries is still very limited with a few notable exceptions that include Moreno Monroy (2008, 2011) for China, Moncarz (2007) for Argentina and Paredes (2015) for Chile[12]. Following Brakmn et al. (2004), Moreno-Monroy (2011) relaxed the real wage equalization assumption and finds evidence in support of the Helpman-Hanson NEG model. The results reveal estimates σ ranging between 2.63 and 3.86, as well as τ ranging between 0.45 and 0.97. On the contrary, Moncarz (2007) and Paredes (2015) failed to find strong evidence in support of the Helpman-Hanson model, even after controlling for other potential explanations[13]. However, inclusion of alternative controls revealed a key feature of developing countries. For example, Paredes (2015) finds that the spatial distribution of wages across regions in Chile, a country highly endowed with natural resources was better explained by amenities (natural resource availability) than market potential. Wages in mining and farming regions of Chile are found to be comparable or higher than wages in metropolitan regions where industrial and service activities are concentrated (Paredes & Iturra, 2012; Paredes, 2013). Paredes (2015) concluded that the case of Chile, is poorly explained by the NEG theory.

[12] While there exist a few studies that have tested the validity of the NEG theory based on Hanson (1998) approach which led to the Helpman-Hanson model for developing countries, a number of studies have tested the NEG theory in different developing countries based on Redding & Venables (2004) approach, which estimates a market potential index using estimates from a gravity trade model estimated using bilateral trade data estimated. While index can be decomposed into market access and supplier access indices, its greatest limitation for a regional analysis is its assumption of labour immobility.

[13] Paredes's (2015) results reveal parameter estimates of σ ranging between 41.8 and 46.01, μ ranging between 0.76 and 0.86, as well as τ ranging between 0.001 and 0.029. While these parameter estimates are within the ranges specified by the Helpman-Hanson model, the no-black-hole condition which is crucial for overall assessment of the validity of the model is rejected. This suggests that exogenous endowments as opposed to transport costs play an important role in the determination of wages across regions in Chile.

Based on Paredes's (2015) findings, it seems clear that, while studies using data for developed economies provide overwhelming evidence in support of the NEG theory, this theory is not necessarily well-suited for some developing countries. The following question then arises: can the NEG theory explain the observed regional wage disparities in emerging economies like South Africa where a complex set of factors seem to influence regional wage levels?

4. Empirical framework

This paper empirically tests the Helpman-Hanson model given by equation (4). To estimate the equation a transport cost function to capture the interactions among regions need to be defined. While Hanson (1998; 2005) captured transport costs with an exponential distance decay function, $T_{ir} = e^{-\tau d_{ir}}$, in this paper we use a distance power function given by T_{ir}=$d_{ir}^{-\tau}$. As argued by Mion (2004), the distance power function is empirically appealing given its strong theoretical foundations within gravity trade models that have been used to provide insights into NEG models[14]. Inserting the distance power function, taking logs and imposing restrictions[15] to equation (4) parameters we derive the following reduced form equation that we used as the baseline model:

$$\log(w_r) = \alpha_0 + \alpha_1 log\left[\sum_{i=1} Y_i^{\frac{1}{\alpha_1}-\alpha_2} H_i^{\frac{1}{\alpha_1}-1-\alpha_2} w_i^{\alpha_2} d_{ri}^{\alpha_3}\right] + \varepsilon_r \quad (5)$$

The dependent variable, $\log(w_r)$ is log wage per worker in regions r. α_0 is a function of constants (σ, μ, τ, f) and the equilibrium real wage, ω. Y_i, H_i and w_i capture income, housing stocks and wages in region i respectively. d_{ir} is distance between region i and r, that is used to proxy transport costs under the distance power function and ε_r is the regression error term.

As with equation 4, equation 5 captures the notion of a spatial wage structure where wages increase as one moves closer to centres of production characterised by high market potential. While the importance of market potential is confirmed by a positive and significant α_1 coefficient ($\alpha_1 > 0$), estimation of the other reduced-form coefficients, α_2, and α_3 enable us to explicitly derive the structural parameters (σ, μ, τ) of the Helpman-Hanson model. A positive

[14] For robustness checks we also estimated the model using the exponential distance decay function. While the magnitude of the estimates differs between the functions, we get similar conclusions from the two functions.

[15] The following restrictions are imposed on equation (4) to get the follows reduced-form parameters:$\alpha_2 = (\sigma - 1)/\mu$, $\frac{1}{\alpha_1} - \alpha_2 = \sigma + \frac{1-\sigma}{\mu}$; $\frac{1}{\alpha_1} - 1 - \alpha_2 = (\mu - 1)(\sigma - 1)/\mu$ and $\alpha_3 = -\tau(\sigma - 1)$. These restrictions are important as they reduce the high nonlinearity of the model which can affect convergence of the model.

and significant wage coefficient ($\alpha_2 > 0$) and a negative and significant estimate for distance coefficient ($\alpha_3 < 0$) is expected.

Given the nonlinearity of equation (5), we follow existing literature (Hanson, 1998, 2005; Roos, 2001; Brakman et al. 2004) and estimate the equation based on nonlinear least-squares (NLS) method. The main advantage of the NLS method is that it allows direct estimation of the nonlinear relationship between regional wages and market potential without having to linearise the model (Cieślik & Rokicki, 2016). Moreso, the method takes in to account the constraints due to the links between the model parameters.

We test the robustness of the baseline model in various ways. First, we extend the baseline model by controlling for various regional specific factors to fully account for the causes of regional disparities in income per worker. As controls, we include measures of human capital, natural resources, climatic conditions, labour market conditions and historical events[16]. Second, we test the robustness of the results from the extended model to potential bias due (1) to reverse causality and (2) to the inclusion of non-competitive sectors.

5. The Data

This study draws on the unique geographically consistent data set constructed using the 1996, 2001 and 2011 full population censuses, as well as from the month-by-month climate data produced by the Climatic Research Unit (CRU) - University of East Anglia (Harris, Jones, Osborn, & Lister, 2014). The information in this data set is aggregated to 354 magisterial districts (hereinafter – regions).

The estimation of equation (5) requires data on wage per worker (w_r), income (Y_r), housing stocks (H_r), and distance (d_{ri}). Given the unavailability of wage data in our dataset we follow existing literature (Redding & Venables, 2004; Bosker & Garretsen, 2012)[17]. and use regional income per worker to proxy for regional wage per worker. Thus, in estimating equation (5) regional income per worker for 1996, 2001 and 2011 is used as the dependent variable. For the different components of the market potential index, which is the key independent variable, we

[16] Definition of the actual variables will be provided in the data section, while the motivation for their inclusion will be given in the empirical results section.

[17] Due to the limited availability of data for wages, in the NEG empirical literature, GDP per capita (Stephen Redding & Venables, 2004), as well as GDP per worker (Bosker & Garretsen, 2012) have also been used as proxy wages.

use total personal income to proxy for each region's income (Y_r), while number of rooms per square km in a dwelling is used to proxy regional housing stocks (H_r). Distance (d_{ri}) is calculated as the great-circle distance (in kilometres) between two points (region i and r)[18].

To test the robustness of the relationship between regional income per worker and market potential, we include the following regional specific factors. First, the share of workers (in total working age population) in each region with at least a tertiary education degree to capture regional differences in human capital[19]. Second, the share of workers in the mining sector in each region to proxy for mineral resource endowments. Third, each region's average yearly temperature and rainfall to proxy for regional climatic differences. These variables are included to capture the effects of local amenities. Fourth, the regional unemployment rate to capture differences in local labour market conditions. Finally, homeland status given by the share of each region's area that falls in a former homeland area to capture effects of historical events.

While the data for composition of human capital, mineral resource endowments, unemployment rate and homeland status came from the full population censuses, data for average yearly temperate and rainfall came from the Climatic Research Unit (CRU) - University of East Anglia climitic database. The summary statistics of all the variables are presented in Table 1A in the appendix.

5.1. The spatial distribution of key model variables

In this section, we provide initial insights on the relationship between regional income per worker and a measure of market potential based on the Harris market potential index given by distance-weighted personal income of each region. This index is not the same as the theory-based market potential function that will be estimated later. We simply use the index to gain initial insights on the potential association between the variables. We start with a visual display of the spatial distribution of income per worker and market potential in Figure 1 across regions in South Africa in the year 2011. On the maps, darker colours reflect higher values, while lighter colours reflect lower values.

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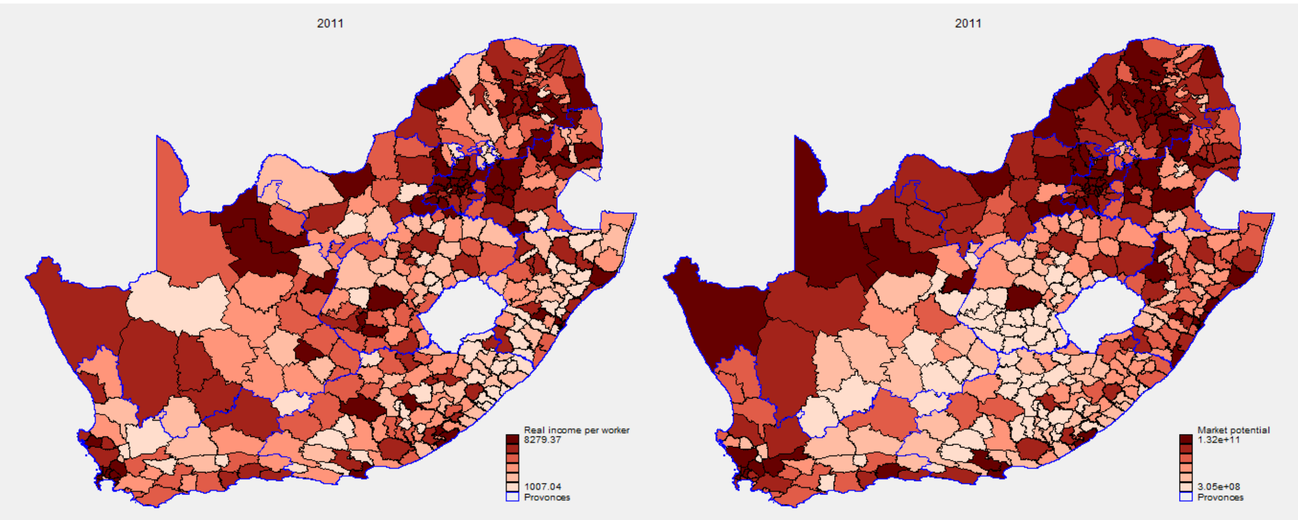
[18] More details on the constriction of the distance variable are provided in PhD thesis from which this paper is extracted.

[19] While this definition of human capital is subject to debate, we check robustness of our definition by using different education cut-off levels, such as considering all workers with at least a matrix qualification. We also use the share of the working age population in each region with at least a tertiary education degree. Regardless of the definition used the importance of human capital remain evident in our analysis.

The maps highlight two key insights. Firstly, income per worker and market potential vary significantly across regions. Secondly, there is clear evidence of spatial concentration of income per worker and market potential across space[20]. For instance, the bulk of regions with relatively high levels of income per worker and market potential tend to concentrate in Gauteng, Western Cape and some coastal cities along the east coast. It is in these areas where economic activities are highly concentrated in South Africa. For example, looking at the 24 regions (out of 354 regions) for Gauteng only, our data shows that, while these regions account for less than 1.5% of the country's total land area, they contribute 22% to national population, 33% to national employment and a massive 40% to total national personal income as of 2011. On the other hand, regions with relatively low levels of income per worker and market potential tend to be clustered at the central parts of the country, as well as some parts of Eastern Cape and KwaZulu Natal.

Figure 1: Distribution of income per worker and market potential across regions



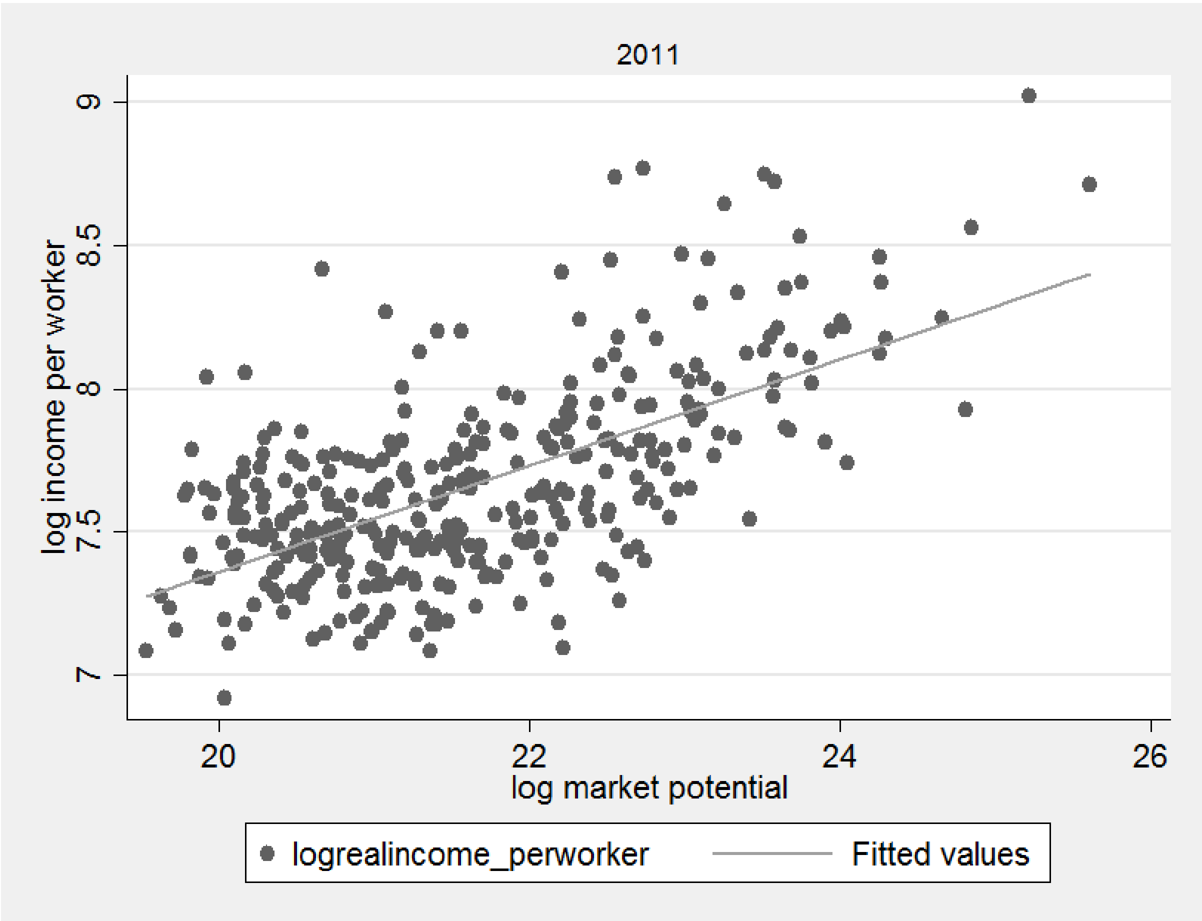
Source: Author's calculations based on census data aggregated to 354 regions.

These distribution patterns suggest the existence of a positive relationship between income per worker and market potential. This relationship is confirmed in Figure 2 that plots the association between regional income per worker and market potential in 2011. A clear positive relationship can be observed, which concurs with the underlying prediction of the NEG wage equation. Nevertheless, a closer look at Figure 1 and 2 suggests that some regions have

[20] The maps showing the spatial distribution of income per worker and market potential in 1996 and 2001 are presented in Appendix 5.1 Figure 5.2A and 5.3 A respectively. Comparing these two figures, we see that the observed spatial patterns mirror those observed in 2011. This suggests evidence of persistent regional disparities and spatial concentration of income per worker and market potential in South Africa.

relatively low (high) levels of income per worker, despite relatively high (low) levels of market potential. The regions in the northern parts of the country, as well as North West and Free State provinces, represent clear examples of these exceptions. This evidence suggests that apart from market potential regional variation in levels of income per worker might be explained by other factors such as mineral resource endowments, wild life activities (high in the northern parts and North West) among other factors. This potentially provides support for the inclusion of other controls in the test of the validity of the NEG model.

Figure 2: Association between regional income per worker and market potential



Source: Author's calculations based on 2011 census data aggregated to 354 magisterial districts.

6. Empirical results

This section presents the results of the empirical analysis in three sub-sections. The first subsection shows the estimation results for our baseline model, equation (5). The second sub-section presents regression results testing the robustness of baseline model to the inclusion of other alternative explanations for regional disparities in income per worker. The last sub-section reports estimates for various sensitivity tests carried out to explore whether our results are robust to potential bias due to reverse causation, as well as the exclusion of non-competitive sectors.

All regressions are estimated using nonlinear least squares method and all standard errors are corrected for heteroscedasticity and autocorrelation[21]. From the different estimations three sets of estimates are obtained, reduced-form, implied structural parameters, and estimates for alternative explanations. Of these estimates, the implied structural parameters are key in the validation of the Helpman-Hanson model. We provide a recap of the conditions the structural parameters need to satisfy in order for the model to be consistent with the case of South Africa in Table 1.

Table 1: Helpman-Hanson model – structural parameter constraints.

Structural parameter	Parameter description
$\alpha_1 > 0.$	Market potential estimate
$\sigma > 1.$	Elasticity of substitution between manufactured varieties
$0 < \mu < 1.$	Share of income devoted to manufactured varieties
$\tau > 0.$	Unit transport cost
$\sigma/(\sigma - 1) > 1.$	Market power condition reflecting imperfect competition
$\sigma(1 - \mu) < 1.$	No-black-hole condition

Notes: These structural parameters are derived from the reduced-form coefficients obtained from estimating equation (5) and (6). Thus, given α_1, α_2 and α_3 the structural parameters are obtained as follows: $\sigma = 1/\alpha_1$, $\mu = (1 - \alpha_1)/\alpha_1\alpha_2$ and $\tau = \alpha_1\alpha_3/(\alpha_1 - 1)$. From these parameters two additional equilibrium conditions given by $\sigma/(\sigma - 1)$ – price-marginal cost ratio and $\sigma(1 - \mu)$ – no black hole condition are also derived.

6.1. Baseline results of the Helpman-Hanson model

Table 2 presents the estimates of the baseline model, equation (5) that includes market potential as the only explanatory variable. Column (1) show estimates for 1996, column (2) for 2001, while column (3) show for 2011. From the reduced-form estimates, the coefficients show that the values of α_1 to α_3 are all statistically significant and consistent with theoretical expectations. The estimated coefficient of market potential (α_1) is positive and significant in all years, suggesting that market potential plays a significant role in explaining differences in income per worker across regions in South Africa. The results show that, a 10% increase in market potential is associated with a 1.13%, 0.98% and 1.7% increase in levels of regional income per worker in 1996, 2001 and 2011 respectively. Consistent with the underlying theory, the estimate of income per worker (α_2) is positive and statistically significant, while that of

[21] In all estimations, initial starting values for the model parameters are needed. These are extracted from existing literature. To ensure robustness of our results, different starting values were used.

distance (α_3) is negative and statistically significant[22]. The negative distance coefficient highlights that as distance to consumer markets increase, levels of income per worker decreases. Thus, remote regions face a market access penalty that lowers their levels of income per worker.

Table 2: Estimation of the Helpman-Hanson Model (NLS method).

Time period	1996	2001	2011
Reduced form coefficients	(1)	(2)	(3)
Log market potential. α_1.	0.113***	0.098***	0.170***
	(0.036)	(0.037)	(0.046)
Log income per worker. α_2.	8.939***	10.511**	5.763***
	(3.015)	(4.183)	(1.710)
Log distance $-\alpha_3$.	-3.103***	-4.250***	-2.209***
	(0.774)	(1.422)	(0.377)
Implied Values			
σ.	8.823***	10.17***	5.897***
	(2.812)	(3.867)	(1.606)
μ.	0.875***	0.872***	0.850***
	(0.020)	(0.022)	(0.027)
τ.	0.397***	0.463***	0.451***
	(0.050)	(0.048)	(0.076)
$\sigma/(\sigma-1)$.	1.128	1.109	1.204
$\sigma(1-\mu)$.	1.102	1.298	0.886
Adjusted R-squared	0.491	0.477	0.416
F-statistic	114.4	108.2	84.88
Obs	354	354	354

Asterisks indicate the level of significance, where: *** p<0.01, ** p<0.05, * p<0.1 and the values in parentheses are Heteroscedasticity and autocorrelation consistent (HAC) standard errors. The estimated model included a constant.

Next, we consider the structural parameters implied by these reduced form estimates. First, the implied values of σ are statistically significant and range between 5.9 and 10.2. The NEG theory assumes $\sigma > 1$, hence these values are in line with the theory. The values of σ suggests that firms across regions in South Africa are operating under increasing returns to scale, enjoying mark-ups (given by $\sigma/\sigma - 1$) of between 10.9 and 20.4. Interestingly, these mark-ups are quite close to other findings from South Africa based on industry and firm data. For example, Zalk (2014) found mark-ups of between 10 and 20 percent, while Aghion, Braun, & Fedderke (2008) found a mark-up of 23.3 percent for the manufacturing sector in South Africa. While the estimates for σ of are higher than the 4.9 to 7.6 range reported for US (Hanson,

[22] We expect α_2 given by $\alpha_2 = (\sigma - 1)/\mu$ to be positive as $\sigma > 1$ and $0 < \mu < 1$.

2005), they are lower than the 41.1 to 46.1 reported for Chile (Paredes, 2015). This suggest that, while US has stronger demand linkages and higher mark-ups than South Africa, Chile has weaker demand linkages and lower mark-ups than South Africa. Thus, the strength of demand linkages emphasized by the Helpman-Hanson model fall as one moves from developed countries towards emerging countries.

The implied value of μ, the share of income devoted to manufactured goods, is statistically significant and satisfies the restriction that $0 < \mu < 1$, suggested by theory across all the years. However, with estimates of μ ranging between 0.85 and 0.88, these values imply only around 0.15 $(1 - \mu)$ of total household income is spent on housing services. As in other studies (Hanson, 2005; Mion, 2005), these values seem to be an overestimation of the share of income devoted to manufactured goods. According to Stats SA, about 32 percent of household total income is devoted to housing, water, electricity, gas and other fuels, with housing services taking up the larger share of the 32% (Stats, 2012)[23].

The estimate of τ is statistically significant and positive ($\tau > 0$) as implied by theory. While the positive (τ) values are consistent with findings in the literature (Paredes, 2015; Mion, 2004; Pires, 2006), it is hard to compare them with other studies due to the sensitivity of τ to the unit of analysis and transport cost function used as well as the way distance is measured. However, a look at the no black hole condition - $\sigma(1 - \mu) < 1$, which determines whether location decisions of economic agents are determined by transport costs or exogenous housing services is rejected in 1996 and 2001, while its only accepted in 2011. As concluded by Kiso (2005), the rejection of the condition in 1996 and 2001 implies that rather than transport costs the spatial distribution of income per worker is determined by the exogenous distribution of housing stocks (other exogenous location factors). On the other hand, since the condition holds in 2011, this implies that transport costs play a key role in the distribution of income per worker across regions.

In summary, while the baseline results reveal parameter estimates consistent with the Helpman-Hanson model, the results fail to provide full support for the model as the no black hole condition fails to hold in 1996 and 2001. Based on this, we can conclude that the case of South

[23] While the 32 percent reported by Stats SA content other components other than housing services, it is most likely that housing costs take the largest proportion.

Africa is poorly explained by the Helpman-Hanson model as the location of economic agents and the spatial distribution of income per worker is determined by the distribution of exogenous location factors as opposed to transport costs.

6.2. Additional controls.

The preceding section shows that the Helpman-Hanson model poorly explains the observed regional disparities in income per worker in South Africa. A key question then is: why does the model not fit the South African case well? A possible explanation is the presence of regional specific factors that also influence the spatial distribution of income per worker across regions.

One compelling source of regional differences in income per worker is regional variation in human capital. The importance of human capital differences in driving regional disparities in levels of wages and other economic outcomes finds support from both theoretical (Becker, 1962; Willis, 1986; Romer, 1986; Lucas, 1988) and empirical literature (Combes, Duranton, & Gobillon, 2008; Fally, Paillacar, & Terra, 2010; Paredes, 2013; Cieślik & Rokicki, 2016). The regional variation in local labour market conditions such as unemployment rate is another potential factor of influence. According to the regional wage curve theory, a negative association exists between the local unemployment rate and regional wage level (Card, 1995; Blanchflower & Oswald, 1990; 2005) and this relationship has been confirmed empirically in different countries including in South Africa (Magruder, 2012; Von Fintel, 2017). Another notable cause of regional wage differences is variation in local amenities. According to the local amenity theory (Roback, 1982, 1988), differences in climatic conditions, natural resources, institutional quality and cost of living all have an effect on levels of productivity, one of the main driving forces behind regional wage disparities (Maza & Villaverde, 2006). Regions with favourable productive local amenities such as valuable natural resources, good access to waterways, favourable climatic conditions, institutions and infrastructure can have higher productivity, which in turn may raise levels of income per worker these regions.

Beyond the sources mentioned above, regional disparities in levels of income per worker may be explained by historical events such as the establishment of the apartheid system from 1948. The apartheid regime implemented several racial segregatory policies where blacks were forcefully relocated and settled into ten homeland areas according to their ethnic groups. These were highly marginalised, overcrowded and distant from economic centres (see Figure 3.1)[24]. The advent of democracy in 1994 led to the end of the apartheid-era rule and the legal reintegration of all homeland areas into South Africa. In addition, numerous regional policy initiatives were implemented to promote regional economic development and address regional economic disparities created by years of apartheid-era rule. Despite this, the legacy of apartheid-era racial segregatory policies may still affect and shape regional distribution of income per worker. This claim finds support in a growing body of research that suggests that distinct historical events have long-lasting effects that continue to shape economic development to this day (Acemoglu & Dell, 2010; Nunn, 2008, 2009, 2014).

Taken together, the factors discussed above might create tensions with the mechanisms put forward by the NEG theory in explaining regional wage levels, which might lead to the poor empirical performance of the theory. To check whether or not this is the case, equation (5) is augmented to capture the effects of regional differences in human capital, local amenities, local labour market conditions and historical events as follows[25]:

$$\log(w_r) = \alpha_0 + \alpha_1 log\left[\sum_{i=1} Y_i^{\frac{1}{\alpha_1}-\alpha_2} H_i^{\frac{1}{\alpha_1}-1-\alpha_2} w_i^{\alpha_2} d_{ri}^{\alpha_3}\right] + \sum_{n=1}^{N} \beta_n X_{rn} + \varepsilon_r \qquad (6)$$

where all the other variables are as defined in equation (5). X_{rn} is a vector of regional controls defined in the data section and β_n is the vector of the corresponding coefficients. Estimating equation (6) enables us to pick the true relations between regional income per worker and market potential as it isolates the effects of regional specific factors.

The results from the empirical test of equation (6) are reported in Table 3. Column (1) shows estimates for 1996, column (2) for 2001, while column (3) shows for 2011. The main insight

[24] The ethnic groups were settled as follows: Transkei and Ciskei (Xhosa ethnicity), KwaZulu (Zulu), Bophuthatswana (Tswana), Venda (Venda), Gazankulu (Tsonga), Lebowa (Sotho), Qwaqwa (Sotho), KaNgwane (Swazi), and KwaNdebele (Sotho). These homeland areas constituted only 13% of South Africa's total land.

[25] If these regional specific factors are constant over time, their effects, as well as effects of other unobserved regional factors can be isolated by estimating a time-differenced version of equation (5) as done by Hanson (1998; 2005). However, apart from loss of information due to time-differencing (Pires, 2006; Cieślik & Rokicki, 2016), several empirical studies reported a poor fit of the wage equation estimated in time-differences (Roos, 2001; Niebuhr, 2006). Indeed, despite the best efforts, estimating a time-differenced version of equation (5) did not provide useful results as the model did not converge for the case of South African. Hence, we decided not to present the results.

from these results is that the inclusion of regional controls improves the fit of the model in all columns as shown by increasing values of the adjusted R squared. Furthermore, the analysis shows that the case of South Africa is well explained by the mechanisms emphasised by the Helpman-Hanson model once we control for regional specific factors. This is confirmed by the no black hole condition which now holds in all columns. Looking at the results in more detail, we see that, while the estimates associated with market potential (both reduced-form and structural parameters) remain significant and consistent with theory, important changes can be seen in these estimates. The sensitivity of the market potential estimates to the inclusion of regional controls suggests the existence of potential bias in the baseline results in Table 5.3.

For instance, the effect of market potential becomes stronger, with the estimate (α_1) increasing from between 0.098 and 0.17 (Table 2) to between 0.23 and 0.34 (Table 3). At the same time, a decrease in the coefficients associated with income per worker from between 5.8 and 10.5 to between 2.7 and distance from between 2.2 and 4.3 to between 0.79 and 1.37 can also be seen. The decrease in the distance estimates highlight that, failure to account for regional specific factors leads to an overestimation of the effects of transport costs. The results are consistent with findings by Hanson (2005) for US who finds increases in market potential estimates (from 0.132 to 0.203), as well as decreases in distance estimates (from 17.91 to 6.43) after inclusion of regional controls. Overall, these results suggest that the effects of the NEG theory in explaining regional differences in income per worker will be underestimated if regional specific factors are not controlled for.

In line with the changes in the reduced form estimates, significant changes can also be seen on the corresponding structural parameters (σ, μ and τ). For instance, σ decreased from between 5.9 and 10.2 (Table 2) to between 2.98 and 4.4 (Table 3). This decrease highlights less competition among firms, which in turn implies higher mark-ups that rise from between 10.9% and 20.4% (Table 2) to between 29.8% and 50.5% (Table 3). Further, the share of income devoted to manufactured goods decreased, suggesting an increase in the share of income spent on housing services from between 0.125 and 0.15 (Table 2) to between 0.179 and 0.267 (Table 3), figures much closer to the 32 percent reported by Stats SA. While the magnitude of these estimates continue to differ significantly from those reported by Paredes (2015) for Chile, there now lies in the range reported by Roos (2001) for Germany, Hanson (2005) US and Pires (2006) for Spain.

Table 3: The Helpman-Hanson Model and additional controls

Year	1996	2001	2011
Log market potential	0,244***	0,230***	0,336***
	(0,071)	(0,065)	(0,100)
Log income per worker	3,779***	4,216***	2,698***
	(1,259)	(1,346)	(0,959)
Log distance	-1,099***	-1,370***	-0,785***
	(0,143)	(0,192)	(0,114)
Implied values			
σ.	4,102***	4,351***	2,979***
	(1,192)	(1,223)	(0,889)
μ.	0,821***	0,795***	0,733***
	(0,045)	(0,038)	(0,071)
τ.	0,354***	0,409***	0,397**
	(0,108)	(0,105)	(0,167)
$\sigma/(\sigma-1)$.	1,322	1,298	1,505
$\sigma(1-\ \mu)$.	0,735	0,893	0,794
Additional controls			
Human capital			
Skilled workers (%)	3,540***	2,345***	2,732***
	(0,345)	(0,241)	(0,166)
Local amenities			
Mining resource endowments (%)	0,358***	0,823***	0,836***
	(0,088)	(0,154)	(0,176)
Log temperature	0,638***	0,706***	0,309***
	(0,123)	(0,146)	(0,109)
Log rainfall	-0,062**	-0,072	-0,027
	(0,031)	(0,048)	(0,040)
Local labour market condition			
Unemployment rate (%)	-0,542***	-0,219	-0,912***
	(0,097)	(0,138)	(0,162)
Historical event			
Homeland status (%)	-0,176***	-0,341***	-0,354***
	(0,040	(0,060)	(0,041)
Adjusted R-squared	0,736	0,664	0,757
F-statistic	99,413	70,774	111,126
Obs	354	354	354

Asterisks indicate the level of significance, where: *** p<0.01, ** p<0.05, * p<0.1 and the values in parentheses are Heteroscedasticity and autocorrelation consistent (HAC) standard errors. Estimated models included a constant.

Even more interesting, the interplay of the key model parameters (σ and μ) now provide evidence in support of the no black hold condition for all the years. This suggests that, once we account for the effects of regional controls, the interplay of transport costs with agglomeration and dispersion forces now play an important role in explaining regional dispersion in levels of income per worker in South Africa. With transport costs now playing a key role, as predicted by Helpman (1998) the increase in transport costs (τ) between 1996 and 2001 points to increasing agglomeration of economic agents in centres of production, which in turn suggest an increase in regional disparities in levels of income per worker. Its slight decrease between 2001 and 2011 suggests a decrease in agglomeration of economic agents, which in turn points to slight decrease in regional disparities in levels of income per worker. These dynamics are consistent with our earlier findings in paper 4, where our results showed evidence of regional divergence in levels of income per worker over the period 1996-2001, as well as regional convergence over the 2001-2011 period.

Turning to effects of included controls. Notwithstanding the few variables that turn out insignificant in some columns, the estimates in Table 3 clearly show that regional specific factors play an important role in explaining observed regional disparities in levels of income per worker across regions over the period 1996-2011. In particular, the coefficient of skilled workers is positive and statistically significant at the 1% level in all columns. On average, if the share of workers with at least a tertiary education degree increase by 1%, regional income per worker increase by between 2.3% and 3.5%. This result is consistent with existing empirical literature that finds evidence in support of the importance of skills composition on explaining regional wage disparities (Combes, Duranton, & Gobillon, 2008; Huang & Chand, 2015).

In addition, in all columns, the estimate for mining resource endowments is statistically significant and positive, suggesting that if the share of workers in the mining sector increases by 1%, income per worker increases by between 0.36% and 0.84% over the study period. In addition, the coefficient of regional average temperature is positive and statistically significant in all the years, suggesting that a 1% increase in average yearly temperature is associated with between 0.31% and 0.71% increase in levels of regional income per worker. Finally, the estimate for rainfall is negative but only significant in column (1), suggesting that a 1% increase in average yearly rainfall is associated with a 0.062% decrease in levels of income per worker in 1996.

Furthermore, apart from column (2), estimates of regional unemployment rate are negative and statistically significant, suggesting that an increase in the local unemployment rate by 1% is associated with between 0.54% and 0.91% decrease in regional income per worker. This result supports earlier findings in South Africa by von Fintel (2017) who finds a negative relationship between local unemployment rate and mean wages. Finally, homeland status estimates are negative and statistically significant in all columns, suggesting that an increase of 1% in the proportion of each region's area that falls in former homeland areas reduce regional income per worker by between 0.18% and 0.35%. The statistical significance of the homeland status variable suggests that, despite the abolish of apartheid-era rule and reintegration of homeland areas with other regions in South Africa in 1994, the legacy of apartheid-era rule continue to negatively affect the level of income per worker of regions in former homeland areas[26].

In summary, three key points can be drawn from this section. First, the Helpman-Hanson model alone is not sufficient to explain observed regional disparities in levels of income per worker in an emerging economy like South Africa. Second, the combination of increasing returns to scale, transport costs and demand patterns create forces that, together with regional specific factors, determine the distribution of income per worker across regions in South Africa. Finally, the NEG theory is not a direct extension toward explaining regional disparities in levels of income per worker in emerging countries like South Africa and its proper application hinges on the incorporation of other regional specific factors unique to those countries. Thus, the results in this section highlight the need for extending the Helpman-Hanson model with additional explanatory factors when applied to emerging economies like South Africa where several factors neglected by the NEG theory also matter in the distribution of income per worker.

6.3. Robustness Checks

This section presents some robustness and sensitivity tests of the results reported in Table 3 to potential bias due to: (1) reverse causality and (2) inclusion of non-competitive sectors.

Reverse causality issues

The results in Table 3 might be biased due to problems of reverse causality arising from two main sources. First, regional income per worker w_r is present on both (left and right) sides of the equation. Hence, act as the dependent, as well as independent variable in the model. Secondly, regional income per worker w_r is also a component of regional total income Y_r. The standard approach to deal with the potential bias due to reverse causality is to use instrumental

[26] Given that apartheid-era rule provided inferior education system and underdeveloped labour markets in homeland areas, it is most likely that these areas are also characterised by low proportion of skilled workers, as well as high unemployment rates. Thus, homeland status and unemployment rate are likely to have a larger negative cumulative effect on regional income per worker.

variable (IV) technique. However, it is difficult to come up with good, reliable instrumental variables given that most economic variables are endogenous as well (Redding, 2010). Furthermore, the nonlinear functional form of the wage equation makes estimations incorporating instrumental variables extremely complicated and the convergence of the models was not achieved[27]. An alternative way to reduce the potential bias due to reverse causality would be to calculate market potential excluding own region market potential (removing Y_r, H_r, w_r and d_{rr}). However, excluding internal market potential would introduce measurement error by considerably reducing the market potential measure of some of the economically larger locations (Breinlich, 2006), such as Gauteng.

For this reason, we choose to keep internal market potential and use the following two strategies to check the robustness of the results in Table 3 to potential bias due to reverse causality. We follow López-Rodríguez & Faíña (2006) and use total regional population instead of total regional income which content wages to measure each region's market size. This reduces the possible correlation between market potential and the error term as regional population is strongly correlated with regional income, but less correlated with regional income per worker (see Table 2A in the appendix).

The results presented in Table 4 show that the estimates of market potential are robust to use of regional total population as a measure of regional market size in all the years. The estimates remain statistically significant and highly consistent with the underlying theory. The point estimates in Table 4 are not significantly different from those reported in table 3. Where they differ, they lie well-within the 95-percent confidence interval of the initial estimates. In addition, the importance of additional controls remains evident.

Acknowledging that the main source of reverse causality might be between regional income per worker and market potential for the same year, as a further robustness check of the results in Table 3, we use historical data in constructing the market potential index. Specifically, we construct a market potential index based on 5, 10 and 15 year lagged data[28]. This enables us to use regional income per worker for 2001 and market potential for 1996; regional income per

[27] Moreno-Monroy (2008), as well as Paredes (2015) also experienced the same problem of convergence of the model for the case of China and Chile respectively.
[28] Taking longer time-lags has the advantage of reducing problems associated with shocks that are to some extent correlated over time.

worker for 2011 and market potential for 2001, and regional income per worker for 1996 and market potential for 2011. This strategy should reduce the correlation between market potential and the error term significantly. The results are reported in Table 5.

Table 4: Sensitivity tests – Use of regional total population (NLS).

Year	1996	2001	2011
Market potential. α_1.	0.226***	0.254***	0.294***
	(0.045)	(0.048)	(0.078)
Income per worker. α_3.	4.044***	3.682***	3.126***
	(0.934)	(0.822)	(0.980)
Distance $-\ \alpha_2$.	-1.168***	-1.327***	-0.849***
	(0.123)	(0.127)	(0.109)
Implied parameters			
σ.	4.432***	3.937***	3.407***
	(0.889)	(0.743)	(0.900)
μ.	0.849***	0.798***	0.770***
	(0.031)	(0.027)	(0.051)
τ.	0.340***	0.452***	0.353***
	(0.075)	(0.092)	(0.133)
$\sigma/(\sigma-1)$.	1.291	1.340	1.416
$\sigma(1-\mu)$.	0.670	0.797	0.784
Control variables			
Human capital			
Skilled workers (%)	3.524***	2.372***	2.710***
	(0.347)	(0.244)	(0.165)
Local amenities			
Mineral resource endowment (%)	0.357***	0.802***	0.840***
	(0.088)	(0.153)	(0.176)
Log temperature	0.612***	0.669***	0.297***
	(0.120)	(0.147)	(0.105)
Log rainfall	-0.080**	-0.107**	-0.029
	(0.033)	(0.051)	(0.041)
Local labour market conditions			
Unemployment rate (%)	-0.554***	-0.281***	-0.908***
	(0.096)	(0.146)	(0.162)
Historical event			
Homeland status (%)	-0.175***	-0.335***	-0.355***
	(0.040)	(0.059)	(0.041)
Adjusted R-squared	0.739	0.669	0.757
F-statistic	100.71	72.23	111.06
Obs	354	354	354

Notes: Asterisks indicates the level of significance, where: *** p<0.01, ** p<0.05, * p<0.1 and the values in parentheses are Heteroscedasticity and autocorrelation consistent (HAC) standard errors. Estimated models included a constant. Column (1) reports estimates for 1996, (2) for 2001, and (3) for 2011 when we replace regional total income with regional total population.

While the results show some variability in the market potential estimates, the general conclusions remain as before. The estimates not only lie in the range of those reported in table 3 but also retain both economic and statistical significance, suggesting that the results in Table 3 are robust to use of historical data. As before, the importance of additional controls is also evident. The observed small changes in these estimates are consistent with findings by Amiti & Cameron (2007), as well as Martinez-Galarraga et al. (2015) who also finds marginally changes to initials market potential estimates after using historical explanatory variables, as well as regional population.

Table 5: Sensitivity tests – Use of lagged values (NLS).

Parameters	5-year lag	10-year lag	15-year lag
Market potential. α_1.	0.197***	0.207***	0.240***
	(0.049)	(0.037)	(0.042)
Income per worker. α_3.	4.618***	4.499***	3.947***
	(1.301)	(0.901)	(0.812)
Distance $-\alpha_2$.	-1.571***	-1.425***	-1.479***
	(0.208)	(0.115)	(0.131)
Implied Values			
σ.	5.072***	4.830***	4.175***
	(1.260)	(0.853)	(0.732)
μ.	0.882***	0.851***	0.804***
	(0.030)	(0.023)	(0.023)
τ.	0.386***	0.372***	0.466***
	(0.081)	(0.066)	(0.081)
$\sigma/(\sigma-1)$.	1.246	1.261	1.315
$\sigma(1-\mu)$.	0.600	0.719	0.817
Control variables			
Human capital			
Skilled workers	4.099***	3.707***	2.391***
	(0.466)	(0.343)	(0.245)
Local amenities			
Mineral endowments	0.485***	0.388***	0.854***
	(0.102)	(0.090)	(0.160)
Temperature	0.590***	0.560***	0.596***
	(0.154)	(0.123)	(0.151)
Rainfall	-0.109**	-0.083**	-0.115**
	(0.045)	(0.033)	(0.050)
Local labour market conditions			
Unemployment rate	-0.034	-0.321	-0.348**
	(0.136)	(0.090)	(0.135)
Historical event			
Homeland status	-0.303***	-0.170***	-0.349***

	(0.064)	(0.044)	(0.062)
Adjusted R-squared	0.595	0.719	0.664
F-statistic	58.732	101.255	78.532
Obs	354	354	354

Notes: Asterisks indicates the level of significance, where: *** p<0.01, ** p<0.05, * p<0.1 and the values in parentheses are Heteroscedasticity and autocorrelation consistent (HAC) standard errors. Estimated models included a constant. Column (1) reports estimates where the variables are regional income per worker for 2001 and market potential for 1996; column (2) variables are regional income per worker for 2011 and market potential for 2001, and column (3) variables are regional income per worker for 1996.

Sectoral analysis

Based on the results in table 4 and 5, it seems clear that potential bias due to reverse causality might not be a major issue in the results reported in table 3. However, the results might still be biased because of inclusion of non-competitive sectors. It is the case that, while our results this far include information from all sectors of the economy, the mechanisms put forward by the NEG theory might be distorted by the inclusion of non-competitive sectors such as public sector and all those sectors classified by Stat SA under "Community; social and personal services"[29]. The mechanisms driving demand and supply in these sectors are not truly driven by market forces. On the other hand, the mechanisms put forward by the NEG theory are more appropriate for manufacturing, which is the key sector driving agglomeration in most NEG models through the interplay of increasing returns to scale, transport costs and demand patterns. Thus, we test the robustness of the results in Table 2 and 3 to exclusion of non-competitive sectors by focusing on the manufacturing sector, which is closely related to the NEG theory.

The estimation results are presented in Table 6. Due to unavailable of sectoral data in the full national population census for 2011, as well as implausible results for 1996 we only present estimates based on 2001 data. The results in column (1) show that the case of South Africa is well explained by the mechanisms emphasised by the Helpman-Hanson model once we narrow down to the manufacturing sector. The analysis clearly shows that the interplay of the key model parameters (σ and μ) provide evidence in support of the no black hold condition even without controlling for regional specific factors. Whereas the bulk of the estimates in column (1) of Table 6 are roughly similar to those in column (2) of Table 2 a major difference can be seen on the transport cost parameter, τ, which increased from 0.46 to 0.73. The apparent

[29] By non-competitive sectors we refer to sectors classified in the censuses as "Community; social and personal services", which includes Public administration and defence activities, Education, Health and social work, other community; social and personal service activities, Activities of membership organisations and Recreational; cultural and sporting activities.

increase in τ highlights that transport costs are higher when we focus on manufacturing sector only. This is to be expected given that manufactured goods are highly tradable, hence firms incur trade costs shipping the goods across regions. As a result of high transport cost, the NEG theory predicts that, manufacturing firms will spatially concentrate in urban areas where demand for their products is high to save on transport costs and enjoy large-scale production (Kosfeld & Eckey, 2010).

Table 6: The Helpman-Hanson Model– Manufacturing sector analysis – 2001, (NLS).

	Without controls	With controls
Market potential. α_1.	0.109**	0.150***
	(0.047)	(0.047)
Income per worker. α_3.	9.014**	6.418***
	(4.077)	(2.163)
Distance $-\ \alpha_2$.	-6.014**	-4.327***
	(2.478)	(1.157)
Implied Values		
σ.	9.195**	6.645***
	(3.976)	(2.085)
μ.	0.909***	0.880***
	(0.031)	(0.030)
τ.	0.734***	0.767***
	(0.061	(0.091)
$\sigma/(\sigma-1)$.	1.122	1.177
$\sigma(1-\ \mu)$.	0.836	0.800
Control variables		
Human Capital		
Skilled workers (%)		0.660**
		(0.310)
Local amenities		
Mineral resource endowment (%)		0.986***
		(0.330)
Log temperature		0.721***
		(0.214)
Log rainfall		-0.142
		(0.094)
Labour market conditions		
Unemployment rate (%)		-0.432*
		(0.235)
Historical events		
Homeland status (%)		-0.347***
		(0.095)
Adjusted R-squared	0.543	0.625
F-statistic	140.88	59.87

Obs	354	354

Asterisks indicate the level of significance, where: *** p<0.01, ** p<0.05, * p<0.1 and the values in parentheses are Heteroscedasticity and autocorrelation consistent (HAC) standard errors. Estimated models included a constant. Based on equation (9), column (1) reports estimates for all sectors, while column (2) focuses on the manufacturing sector and column (3) on the services sector. All estimates are based on 2001 data.

Furthermore, the results in column (2) continue to show evidence of the importance of regional specific factors in explaining regional disparities in levels of income per worker. As before the estimates show that failure to account for alternative factors leads to biased estimates, with the effect of market potential underestimated. From this analysis, we can, therefore, conclude that manufacturing sector provides clear evidence in support of the Helpman-Hanson model, as before, however, alternative theories cannot be left out of the analysis. As a result, whether we focus on all sectors or manufacturing sector, it is the interaction of increasing returns to scale, transport costs and love of variety that, together with regional specific factors, explain the observed disparities in levels of income per worker across regions in South Africa.

7. Conclusions

This paper sets out to empirically test whether the prediction of a wage equation derived from the new economic geography (NEG) theory is consistent with the observed regional wage disparities in South Africa. The study draws on a novel regional data set constructed using 1996, 2001 and 2011 full population census data and use regional income per worker to proxy for regional wage per worker. Whereas the bulk of existing regional studies in South Africa tend to estimate reduced-form equations incorporating variables inspired by the NEG theory, a major contribution of this study is the estimation of a structural wage equation based on the Helpman-Hanson model derived directly from the NEG theory. By estimating this model, the study makes an important contribution to the NEG empirical literature, which is currently limited in the context of Africa. The study reveals several important findings.

Firstly, the analysis provides evidence of a highly significant and positive relationship between regional income per worker and market potential over the period 1996 – 2011 as postulated by the NEG theory. This suggests that regional income per worker in South Africa tend to rise with increasing market potential of the region. In addition, the study finds evidence of highly significant and theoretically consistent structural parameters (σ, μ and τ) of the Helpman-Hanson model. In spite of this evidence which seems to strengthen the importance of market potential in the determination of regional income per worker, a key condition critical in the validation of the Helpman-Hanson model, the no black hole condition, $\sigma(1-\mu) < 1$ is rejected for 1996 and 2001. This suggests that the case of South Africa is poorly explained by the mechanisms emphasised by the Helpman-Hanson model. This evidence is consistent with findings from other emerging economies (Alvarado & Atienza, 2014; Paredes, 2015).

Secondly, the results indicate that the case of South Africa is well explained by the mechanisms emphasised by the Helpman-Hanson model only after controlling for regional specific factors such as human capital, mineral resources, local climatic conditions, local unemployment and homeland status. The inclusion of these controls improves the fit of the model, leading to precise market potential estimates (both reduced-form and structural parameters), which lie in the range reported by previous studies (Hanson, 2005, Pires, 2006). The results reveal that the effect of market potential become stronger, while the no black hole condition now holds for all the years once we control for regional specific factors. This suggests that, once the effect of regional specific factors is isolated, the mechanisms emphasised by the Helpman-Hanson model play an important role in explaining regional dispersion in levels of income per worker in South Africa. Based on these findings we can conclude that neglecting regional specific factors can seriously bias market potential estimates, in the process compromising the empirical performance of the Helpman-Hanson model.

Thirdly, the study shows evidence of increasing importance of market potential over time. The results show evidence of an increase in the market potential estimate from 0.24 to 0.34 between 1996 and 2011, suggesting growing demand linkages across regions over time. The revealed market potential estimates, however, show that the strength of demand linkages emphasised by the Helpman-Hanson model are relatively weak for South Africa compared to developed economies like U.S and Japan, but relatively strong compared to other emerging economies like Chile and Ecuador (see Hanson, 2005; Kiso, 2005; Alvarado, Atienza, & others, 2014; Paredes, 2015).

Finally, a further analysis shows that the results above are robust to a set of sensitivity tests carried out to test the extent of potential bias due to reverse causality. However, the sensitivity test of inclusion of non-competitive sectors shows that focusing on manufacturing sector provides clear evidence in support of the Helpman-Hanson model even without controlling for regional specific factors. The results, however, show that alternative theories cannot be left out in the analysis as failure to account for regional specific factors can lead to underestimation of the effect of market potential.

From this analysis, we can, therefore, conclude although the mechanisms put forward by the Helpman-Hanson model are appropriate, there are not sufficient to fully explain observed regional disparities in levels of income per worker in an emerging economy like South Africa. It is the interplay of increasing returns to scale, transport costs and demand patterns as postulated by the NEG theory that, together with human capital, mineral resources, local climatic conditions, local unemployment and homeland status that fully explains the spatial distribution of income per worker across regions in South Africa. Thus, the prediction of the NEG wage equation holds for the case of South Africa only after inclusion of alternative explanatory factors. This finding is consistent with earlier results in Paper 3 were the revealed spatial patterns in the distribution of income per worker suggested the co-existence of NEG theory (positive autocorrelation) and standard economic theory (negative autocorrelation) features in the South African data.

The findings of this study have important empirical, theoretical and policy implications. From an empirical perspective, the Helpman-Hanson model is not a direct extension toward explaining regional disparities in levels of income per worker in emerging countries like South Africa. Its proper application hinges on the incorporation of other regional specific factors unique to emerging economies. From, a theoretical perspective, the evidence points to the need for extending NEG models to incorporate additional explanatory factors unique to emerging economies. Finally, from a policy perspective, the results highlight the need for regional policy initiatives that promote greater access to markets. To achieve this, policy measures can target increasing returns to scale, transport costs and love of variety which are the precise channels through which market potential influences regional income per worker and overall economic development. Furthermore, the findings point to the need for regional policy initiatives that foster human capital accumulation and improves labour market outcomes especially for lagging regions mainly in former homeland areas that remain highly marginalised.

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Appendix

Table 7A: Summary Statistics of key variables (1996-2011).

Variable	Obs	Mean	Std. Dev.	Min	Max
Income per worker	1062	7.481	0.387	6.340	9.023
Market potential	1062	20.66	1.360	18.02	25.61
Total personal income	1062	17.57	1.628	14.10	23.09
Total housing stocks	1062	11.006	1.267	8.084	14.59
Distance	125316	601.4	362.5	2.5	1795.5
Total population	1062	11.07	1.255	8.130	14.17
Average temperature	1062	2.861	0.131	2.244	3.160
Average rainfall	1062	4.006	0.431	1.960	4.825
Share higher education	1062	0.053	0.039	0.004	0.312
Unemployment rate	1062	0.374	0.168	0.0279	0.841
Homeland status	1062	0.253	0.396	0	1
Share of mining workers	708	0.039	0.098	0	0.838
Share of manu workers	708	0.076	0.063	0.001	0.352
Share of agric workers	708	0.220	0.178	0.003	0.795

Note: The summary statistics are for data for the entire sample period (1996-2011) pooled together so that for each variable we have the average value for 1996, 2001 and 2011 data. Of these variables income per worker, market potential, total personal income, total population, total housing stocks, average temperature and rainfall are in logs. Distance is in levels for a 354 x 354 matrix. Share of higher education, share of mining workers, share of agric workers, share of manu workers, and homeland status variables are shares, unemployment rate is a proportion.

Table 8A: Correlation coefficients.

	Income per worker	Total personal income	Total population
Income per worker	1.0000		
Total personal income	0.7387	1.0000	
Total population	0.4025	0.8236	1.0000

Note: Variables are in levels and are for the entire sample period (1996–2011). Thus, the correlation coefficient is an average value for 1996, 2001 and 2011 data.

Figure 3A: Spatial distribution of income per worker & market potential 1996

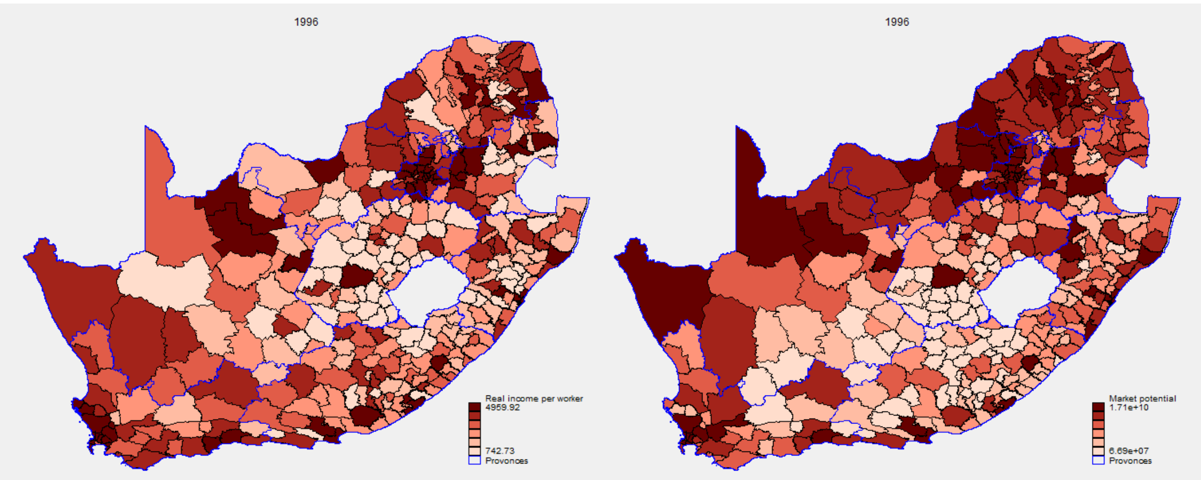

Figure 4A: Spatial distribution of income per worker & market potential 2001

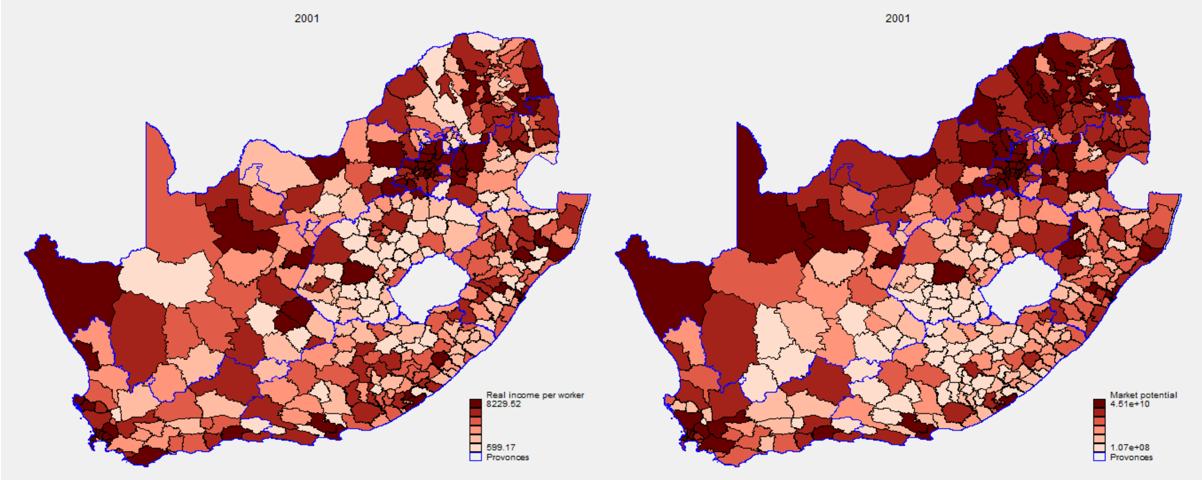

Figure 5A: Association between regional income per worker and market potential