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Spatial Channels and Regional Mechanisms of Dutch Disease in Canadian Economy

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Abstract: Dutch disease is the mechanism through which the boom in one sector induced by an exogenous shock may have profound adversary long-term implications over the economic growth. The windfall gains generated from the commodity price increase leads to real exchange rate appreciation boosting wages and prices across non-related economic domains. As a result, economic growth becomes unsustainable in the long run, while the booming sector experiences diminishing output and shrinkage of resources. The growing interest to the policy methods of strengthening industrial resilience revived the interest in this area. The exhaustive literature concerned with the mechanism of Dutch disease has generally overlooked the hidden spatial and cross-sectoral effects behind its mechanism. It is suggested that evaluating Dutch disease on lower levels of aggregation could be a helpful tool to decouple underlying cross-sectoral effects. This thesis expands the current research by conceptualizing spatial channels and regional mechanisms of the Dutch disease phenomenon. First, methodological approach to account for spatial channels behind Dutch disease is developed using the combination of multivariate cointegration analysis with structural breaks and Bayesian dynamic factor model. Second, the thesis contributes to uncovering factors behind productivity shifts within Canadian economy, across space and sectors, as well as expands current research on disparities emerging between regions with different industrial profiles.

Keywords: Dutch disease, economic growth, productivity gap, regional divergence

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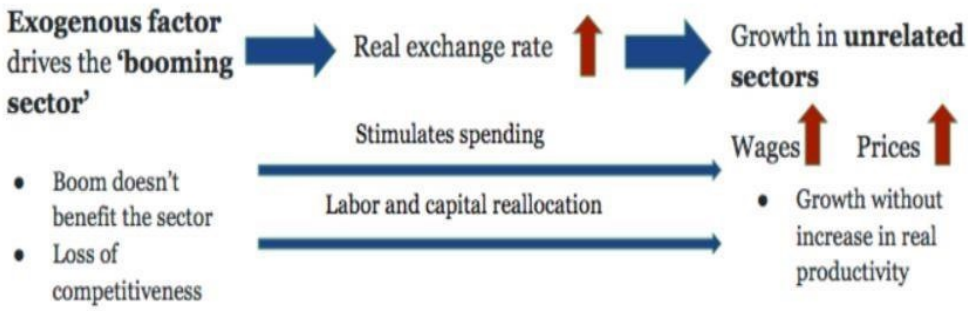
1. Introduction

Divergence in productivity levels across different sectors of economy is an important component in explaining the patterns of economic growth and structural change. The growing strand of research indicates that the rapid productivity growth in one of the industries may have a double-edge effect over the long-term sustainability of economic growth. On the one hand, it can be a driving force for other sectors of economy by accumulating critical mass of endowments that are exploited by other industries, boosting consumption, and becoming the source of direct knowledge, technology, and productivity spillovers (Faderberg, 2000; Torvik, 2001). The stages of ICT diffusion in the 1980s and 1990s whereby the ICT-using sectors were shown to be major contributors to accumulated productivity growth in most of developed countries, is a commonly considered case that gained research attention from the perspective of exploring how productivity gap influences overall economic growth (OECD, 2015). On the other hand, extensive literature indicates the significance of the downward pressure that the boom in one of the sectors may have over the growth in unrelated sectors as well as overall productivity competitiveness of economy through the range of mechanisms (McMillan & Rodrik, 2008).

A particular mechanism through which the 'boom' may have a profound structural impact over the economic growth is through the shift in relative commodity prices, which misaligns the real exchange rate. Particularly, if productivity growth in the 'booming' tradable sector is fuelled by exogenous factors or 'shocks', such as discovery of new resources, real exchange rate appreciation boosts real wages and prices across all sectors of economy (Krugman, 1988). The windfall profit generated from the commodity price increase is actively reallocated to the 'non-core' sectors, ultimately leading to the loss of international competitiveness in the 'booming' sector (The World Bank, 2010). Incentivized by inflated wages, labor resources tend to relocate to the non-core sectors further depriving the booming sector of the capacity to reap benefits from the boom. Since the boost that non-booming sectors receive in this scenario is not underpinned by real change in productivity and technological improvements, growth of these sectors becomes unsustainable in the long run. Such a mechanism has been commonly referred to as a primary symptom of Dutch disease. The concept originated in the 1960s when extensive natural gas explorations in the Netherlands led to drastic decline in the oil and gas and traditional manufacturing industries (Corden & Neary, 1982).

Figure 1. General scheme of the Dutch disease mechanism



Therefore, the general mechanism of Dutch disease presumes *persistent preconditions for resource reallocation from the booming sector to the non-booming sectors that experience inflated wage and prices. The fundamental assumptions of the Dutch disease scenario are (1) the boom is driven by an exogenous factor; (2) an exogenous factor is significant enough to spur real exchange rate.* At the national-economy level, the real exchange rate appreciation itself significantly impedes overall economic growth, which is overwhelmingly supported by the cross-country statistical evidence (Rodrik, 2008; Magud & Sosa, 2010). At the sectoral level, symptoms of Dutch disease influence the economic growth through three major effects; (1) resource mobility effect – relocation of labor and capital resources from the booming sector to the non-booming ones, as described above; (2) spending effect – share of investments allocated to the non-core sectors; (3) progressive deindustrialization, which takes place despite the further growth in the booming sector (Corden & Neary, 1982). As a combined effect of these mechanisms, accumulated economic growth becomes unsustainable as it is inflated by the productivity bias. The non-tradable sectors experience decrease in international competitiveness in the long run boosted by windfall gains from the booming sector, which in its turn experiences abrupt reduction in the growth potential. On top of that, in most cases, the booming sector is the most innovative one (Algieri, 2011); therefore, additional mechanism through which economic growth is affected by the disease is through lowering innovative capacity of the economy.

Exploring symptoms of Dutch disease and its underlying mechanisms from different perspectives may enrich understanding of structural shifts and economic growth. However, the overwhelming majority of the research is narrowed to testing for disease hypothesis itself rather than uncovering its mechanisms from different angles and connecting it to the broader literature on cross-sectoral spillovers. It was not until recent research that the need to synthesize the model with other factors of economic transition at play was brought up. Particularly, Papyrakis & Raveh (2014) and Rocchi et al. (2015) suggest that exploring the spatial dimension of Dutch disease can contribute to the understanding of regional discrepancies. OECD (2012) suggests that the aggravation in regional disparities could be ascribed to the shifts in energy prices and real exchange rate appreciation, effect of which takes place through cross-regional productivity spillovers. Therefore, further research in this direction will contribute to understanding of the Dutch disease phenomenon as well as contribute to uncovering mechanisms of structural change, spillover effects, and decomposing factors behind productivity growth.

2. Research Background

2.1 Expanding the Dutch Disease Framework

Despite the fact that the recent literature in the strand of research focused on Dutch disease indicates a divergence in approaches to conceptualizing connection between real commodity prices, real exchange rate, and cross-sectoral productivity gaps, certain methodological consistency could be established (Table 1). Particularly, most of research in this domain rest upon *the expanded Balassa-Samuelson effect framework and involve (1) long-run equilibrium testing and (2) output equations estimation*. The original interpretation of the Balassa-Samuelson hypothesis (also referred to as the productivity bias hypothesis) assumes that labor productivity gap between the tradable sector and non-tradable sectors leads to real exchange rate appreciation as it boosts real wages across the entire economy (Egert, 2002). The Dutch disease literature expands the traditional Balassa-Samuelson effect by including two other explanatory components to the long-run equilibrium model of the real exchange rate (Algieri, 2013; Neary, 1985). First is a government component proxy, which represents monetary and fiscal interventions and is most commonly specified in the models through public deficit ratio, government expenditures as a share of gross domestic product or net interest rates (e.g. Bourdet & Falck, 2006; Oomes & Kalcheva, 2007). Second is a 'real shocks' component, which represents macroeconomic shocks that boost consumer spending, namely, gross domestic product growth, income, and terms of trade (defined as changes in relative prices between export and import portfolios). In some studies, other monetary shocks such as changes in net international reserves are controlled for (Dulger et al., 2013). Therefore, according to the most general framework for Dutch disease testing, the real exchange rate dynamics is explained through the long-run equilibrium comprising the following components;

(1) Balassa-Samuelson effect (indicator: labor productivity gap between tradable and non-tradable sectors)

(2) Government component (government expenditures as a share of GDP, public sector deficit, interest rate, net international assets);

(3) Real macroeconomic shocks (GDP growth, national income, terms of trade);

(4) Exogenous factor component (the country-specific Dutch disease proxy, such as oil prices, remittances etc.).

Table 1. Overview of the frameworks applied to explore Dutch disease symptoms

Study	Area of Interest	Period	Model Specification	Estimation Method
Bourdet & Falck (2006)	Cape Verde	1980-2000	Real exchange rate = *f* (remittances; net development assistance per GDP; government policy (growth of domestic credit – lagged GDP growth rate); terms of trade)	VAR-based estimation
Oomes & Kal-cheva (2007)	Russia and CIS	1997-2005	Real exchange rate = *f* (oil prices, productivity gap, government consumption net international reserves, corruption index)	VECM-based estimation
Egert & Leonard (2008)	Kazakhstan	1991-2001	Real exchange rate = *f* (productivity gap; relative prices gap; oil prices; terms of trade / debt-to-GDP / openness)	Cointegration analysis (Engle and Granger tests, DOLS and ARDL models)
Acosta, Lartey & Mandelman (2009)	Salvador	1991-2006	Real exchange rate = *f* (remittances, two-sector technological shock differential, investment prices). Two-sector output gap = *f* (remittances, real exchange rate)	Bayesian VAR model
Issaoui, Boufateh & El Montaser (2013)	OPEC Countries, Japan, Norway, USA	1975-2010	Real exchange rate = *f* (Industrial added value (monetary + real shocks); oil rent differential)	Structural VAR model
Dulger, Lopcu, Burgac & Balli (2013)	Russia	1995-2011	Real exchange rate = *f* (overall productivity; productivity gap; oil prices; output gap). Two-sector output gap = *f* (productivity gap, oil prices)	Johansen cointegration analysis with structural breaks (Gregory-Hansen method)
Esfahani, Mohaddes & Pe-saran (2014)	OPEC members; Mexico and Norway	1979-2006	Two-sector output gap = *f* (oil prices; GPD; foreign output gap; trade balance).	Johansen cointegration analysis, VARX model
Poncela, Senra s& Sierra (2017)	Colombia	1972-2012	Real exchange rate = *f* (overall productivity; commodity prices gap; manufacturing prices; government component, openness, capital inflow). Two-sector output gap (manufacturing/services productivity)	Johansen cointegration analysis, VECM-based estimation

Estimating the long-run equilibrium real exchange rate based on this specification allows testing for the basic precondition of Dutch disease – whether an exogenous factor significantly determines the real exchange rate when controlled for monetary and macroeconomic shocks. Standard multivariate time series analysis techniques are commonly applied to carry out the long-run equilibrium test. Particularly, employing Johansen cointegration test procedure (Johansen, 1995) has been widely applied as a methodological tool for Dutch disease testing having supplanted vector autoregression (VAR) models in more recent research (Dulger et al., 2013). Employment of the cointegration analysis is attributed to its advantage in decoupling short-term and long-term dynamics.

Recent empirical studies often complement testing long-run equilibrium by estimation of two-sector output equations (e.g. Acosta et al., 2009; Esfahani et al., 2014; Poncela et al., 2017). Specifically, the model in which the output gap between two sectors is designated as a function of the Dutch disease proxy (exogenous factor) and productivity gap between respective sectors is estimated. Two-sectoral models enable to test for the presence of the third symptom of Dutch disease – progressive tertiarization (Shakeri, 2009). However, the two-sectoral models have manifested limitations in capacity to account for underlying effects of Dutch disease. Particularly, Bjornland & Thorsrud (2016) identified that indirect productivity spillovers between tradable and non-tradable sectors, which are omitted in the standard framework, could be significant enough to distort the Dutch disease model. Torvik (2001) found that the boom in one sector is accompanied by a continual learning-by-doing mechanism which takes place as non-tradable sectors accrue direct spillovers to serve the booming sector by the wide range of complementary technical solutions (Bjornland & Thorsrud, 2016; Shakeri, 2009). Therefore, learning-by-doing mechanism could be partly responsible for the cross-sectoral movements that are assumed to be associated with Dutch disease symptoms in traditional frameworks.

The current thesis aims at addressing this methodological problem by *extending two-sector models into demand-factor model*. First, learning-by-doing mechanism is accounted for in line with the framework developed by Torvik (2001). Second, it is assumed that indirect productivity spillovers from the booming tradable sector both to other tradable and non-tradable sectors are significant enough to stimulate productivity gap in the short-term and affect real exchange rate.

Particularly, these spillovers could be generated by the movement of common resources (resource base that is used by several or all sectors of economy), which are not captured within traditional frameworks. Further, it is suggested that *evaluating the Dutch disease mechanism on lower levels of aggregation could be a viable approach to decouple underlying cross-sectoral effects*. Major limitation of the Dutch disease modelling is that it has been applied at the country-level case studies. In contrast, the nature of Dutch disease mechanism – sectoral context, dependence on the factors of industrial resilience, focus on linkages and resource movements that form distinct spatiality – suggests relevance of its framework to the regional context. Furthermore, there is a growing evidence that the commodity price differentials at the regional level may have similar magnitude (Kano et al., 2013), persistency and structural effects (Enflo & Roses, 2015) with the cross-country level; that is, employing regional-level of aggregation may benefit current research on Dutch disease mechanisms. This provides a rationale to extend the recent literature by considering cross-regional and spatial channels of Dutch disease in the current thesis.

2.2 Regional and Spatial Mechanisms Behind Dutch Disease

There is a growing research evidence on regional mechanisms of the Dutch disease – scenarios whereas the productivity growth is slackened by positive agglomerative spillovers generated by the externally-induced boom from the resource-intensive regions to regions with non-resource-based profiles. If agglomerative spillovers accrued from the booming economic activity are significant in explaining the regional productivity growth, the upward pressure is created pushing the regional economy to a higher equilibrium output level (OECD, 2012). Therefore, it is important to account for mechanisms of such spillovers – their spatiality, sectoral direction, magnitude and driving forces, to assess sectoral shifts in productivity levels.

Since major channels of Dutch disease – resource movement effect, spending effect and active tertiarization – are manifested through spatial mobility of resources, 'spatializing' Dutch disease would enable capturing underlying cross-sectoral shifts. Particularly, patterns of labor movement, which is a major channel of all three effects, could be more significant than cross-sectoral differences – it is ambiguous to which degree the proximity in industrial profiles between regions plays role in explaining the inter-regional migration patterns. Under scenario of resource boom, spillovers to the non-resource sectors could be partially explained through addressing the cascade of problems; (1) whether the higher income growth in resource-based regions pushes labor reallocation to more tertiarized regions or on the opposite attracts higher human capital from the latter; (2) whether the inter-regional migration patterns contribute to mitigating Dutch disease symptoms; (3) to which extent regional industrial profile, in contrast to institutional and spatial proximity and other factors, predicates the immigration patterns under the resource boom. Labor relocation itself can offset local demand growth creating downward pressure on prices, which builds up rationale to employ demand-factor modelling to Dutch disease testing. On top of that, from the perspective of spending effect, it is important to consider the geography of end beneficiaries of the windfall gains to uncover potential drivers behind the productivity shifts.

Few studies attempted to embed Dutch disease model into the regional-level frameworks. Beine et al. (2015) tested the presence of mitigating effect of immigration through the increase of size in non-booming sectors. The study was based on disentangling labor resources' movement by type of immigration and broadening the framework of cross-sectoral productivity spillovers that take place under a resource boom by considering the direction and magnitude of the migration patterns. The study found that inter-regional immigration to a certain degree mitigates the prices shock to the economy (Beine et al., 2015), while change in international flows of immigration have limited impact over the cross-sectoral productivity shifts. Another recently developed problem area lies in the perspective of disentangling effects of agglomeration and Dutch disease mechanisms. Thus, the agglomeration literature exhaustively indicates that resource booms drive economic transformation in the research-abundant regions through constant productivity spillovers, which counteracts with the crowding out of spillover-generating industrial base as assumed by Dutch disease hypothesis. Allcott & Keniston (2017) applied spatial equilibrium framework evaluating the two-sector model (tradable manufacturing and local manufacturing) with presumption of persistent learning-by-doing mechanisms for both sectors. Based on the US county-level data, it was estimated that resource booms that took place in the 1980s and 1990s did not produce long-term agglomerative effects despite the synchronization between manufacturing wages and prices, on the one side, and oil and gas prices on another.

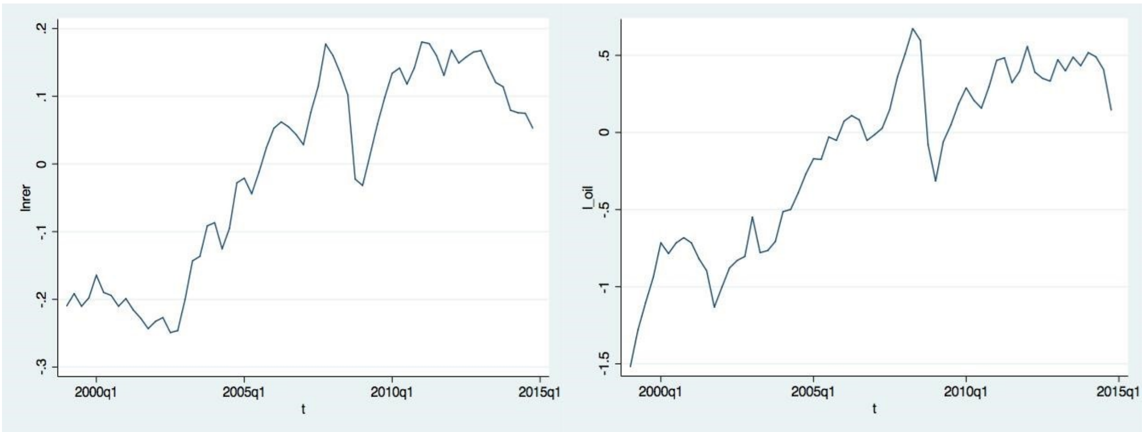
Based on this branch of literature, it could be assumed that the divergence in industry profiles across regions might mirror the Dutch disease mechanisms, while spatial factors of regional divergences may explain the part of productivity gaps. Taking all other conditions equal, a large share of output from industries with high productivity increases the productivity within the local economy. Therefore, exploration of productivity shifts should take into account the variance in industrial profiles of regions, which might be determinant of size and direction of productivity spillovers.

2.3 The Context of Canadian Economy

In the empirical part of the thesis, the regional mechanisms of Dutch Disease are evaluated using the case of Canadian economy. Over the recent decade, there has been a tendency to focus on either transition economies or oil-dependent countries to test Dutch disease (Bjorlund & Thorsrud, 2016). Nevertheless, there is a general research consensus that its symptoms are not idiosyncratic to these types of economies (Cologni & Manera, 2008; Davis, 1995). Furthermore, indications of symptoms' persistence have been reported by national banks in the number of developed countries including Australia and Canada (Corden, 2012; OECD, 2012). Lack of empirical studies employing the context of developed countries is ascribed to the complexity of testing the Dutch disease symptoms for economies with diversified export portfolio. The case of Norway stands out in this respect, having attracted wide research attention as a 'success story' of escaping natural resource curve (Larsen, 2006). Therefore, this thesis aims at contributing to existing research in the area by considering the context of Canadian economy. The Canadian case represents particular research interest in light of "*Canada's productivity paradox*" (OECD, 2012) – the productivity levels have consistently been weaker than in other developed countries and, particularly, the United States; the trend that have persisted since the early 1990s (Basu, 2012). Moreover, Canadian economy is characterized by relatively high level of institutional decentralization and regional disparities in terms of resource abundance. Last, availability of exhaustive regional-level data on industrial dynamics in Canada facilitates using this case to serve the research objective of exploring cross-sectoral effects behind the phenomenon.

Since the start of active resource explorations in the early 1990s, the Canadian energy sector has experienced steady growth with its share in the country's exports having doubled over the period between 1990 and 2014 (from 14 to 28.1 percent, respectively) (The World Bank, 2016). Based on this boom, the degree to which oil and gas prices are integrated into Canadian dollar exchange rate has been widely debated in research and policy domains (e.g. Choudhri & Schembri, 2014; Ferraro et al., 2015; Issa et al., 2015). Canada is not generally viewed as a classical candidate for Dutch disease symptoms considering far more diverse exports profile in comparison to other major oil exporters and since there have been indications of weakening correlation between oil and gas prices and Canadian dollar rate (Issa et al., 2008). Notwithstanding, post-crisis policy debates around the need for strengthening industrial resilience to external shocks pointed to the relevance of testing for the vestiges of Dutch disease in Canadian economy. Particularly, Burleton & Palamatra (2012) estimated that the boost in oil exports and investment in machinery, equipment and infrastructure in the energy sector (to support further exploration of fuel resources) accounted for 30 per cent of economic growth in the post-crisis period (2009-2011). Accounting for direct spillovers and learning-by-doing mechanism – as high investments in infrastructure entailed increase in demand on the wide gamut of non-fuel manufacturing products as well as within tertiary sector (e.g. technical consultancy, transportation, financial services) – this contribution could be even higher.

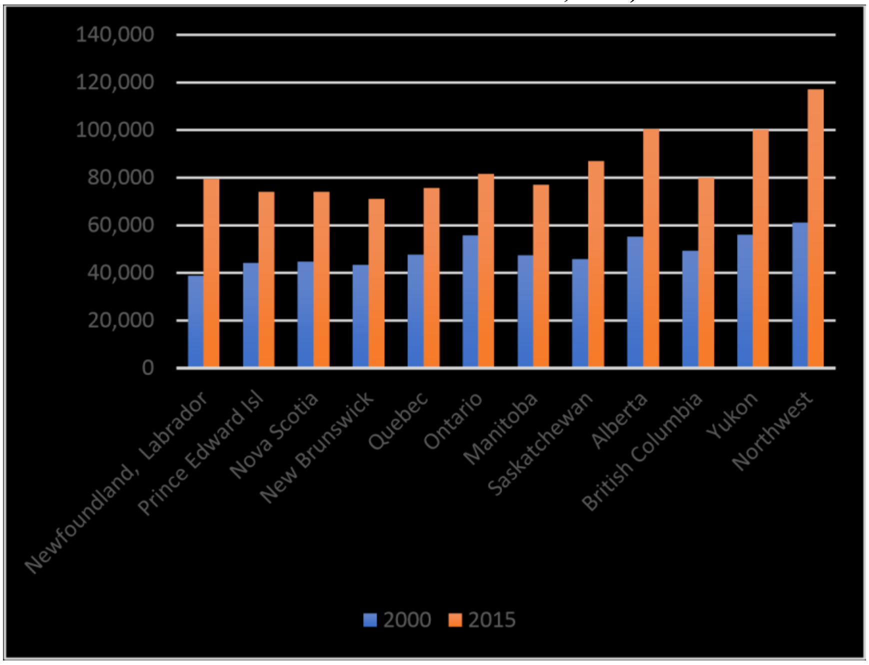
Figure 2. Real exchange rate of Canadian Dollar and oil prices (log-values), 1999-2015



Other potential symptom is a diminishing value added of export-oriented manufacturing sectors (both in contrast to the respective sectors in the US economy and in contrast to non-tradable sectors) and relatively faster decrease in employment share (OECD, 2012). Thus, in OECD Economic Survey (OECD, 2012), it is reported that the share of manufacturing sector in the Canadian economy is heavily influenced by the real exchange rate in contrast to the economies of both the United States and Eurozone. Further, the report stresses the significance of relative prices gap between manufacturing and services sectors in crowding out the share of the former in value added (OECD, 2012). Providing further evidence for this causality, the Canadian Chamber of Commerce identified that a 1-percent appreciation in the Canadian-US dollar exchange rate is associated with 0.016-percent decrease of the manufacturing sector in employment share and 0.041-percent decrease in total output share (period of observation: 2000-2010, The Canadian Chamber of Commerce, 2012). However, even though the correlation between Canadian dollar rate and oil prices is a significant explanatory component in the structural composition of economic growth, the empirical research (e.g. Burleton & Petramala, 2012; Kia, 2013) suggests that factors behind productivity gap in Canadian economy go far beyond this factor.

Foremost, it should be admitted that the Canadian export portfolio is still relatively energy-dependent with energy sector accounting for 28.1 per cent of total exports (The World Bank, 2016). However, low diversification of export portfolio in terms of geographical distribution – still, the United States accounts for 78 per cent of Canadian manufacturing exports and 98 per cent of the exports of crude petroleum (Statistics Canada, 2014) – could have more far-reaching consequences over sectoral dynamics. Hence, slower growth of productivity in Canadian manufacturing sector in comparison to the US might be a primary determinant of the cross-sectoral productivity gap and active tertiarization. Therefore, analysis of the structural problems within the Canadian economy should take into account the divergence in effects that the dynamics in the US markets bring over different sectors of economy. In this regard, assessing international competitiveness of the Canadian manufacturing sector, resilience of the major export-oriented sub-sectors is usually noted out (Baldwin & McDonald, 2009; The Canadian Chamber of Commerce, 2012); however, appreciation of Canadian dollar has a limiting impact over the export diversification potential. Such a development prompted large-scale Canadian manufacturing companies to seek new business opportunities in the domestic market to compensate for the lost positions on the US market.

Figure 3. Average income per household across provinces of Canada (2000,2015; data source: Statistics of Canada, 2015)



Regional divergences in industry composition may explain the large part of the variations in productivity including cross-sectoral gaps. In its turn, regional disparities could be spurred by the differences in industrial dynamics and indicate a linkage between resource booms and productivity gaps (as discussed in 2.2). Thus, OECD report (2012) *attributes aggravation of regional disparities that has been taking place over the last decade to energy prices and real exchange rate dynamics*. It could be presumed that to certain extent, regional structure of Canadian economy mirrors the sectoral productivity gap. Resource-abundant provinces (Alberta, Saskatchewan, British Columbia) have demonstrated higher income growth rates boosted by energy prices. In the same time, these regions have significantly lagged behind in terms of R&D investments from Ontario and Quebec. In line with Freedman (2011), conditions of underinvestment in R&D coupled with high share of resource-based industries create a tendency for relocation of income generated by the energy prices increase to non-core regions, an effect similar to Dutch disease symptom. Distinguishing and estimating such spillover effect would allow expanding understanding of regional divergence, which in its turn would build up a ground for more effective policy intervention. These findings represent a key rationale for studying spatiality and regional mechanisms behind Dutch disease phenomenon and productivity gaps.

2.4 Research Objectives

Considering the gaps and scope of research discussed above, the current thesis is aimed at expanding the standard *Dutch disease framework to capture spatial (cross-regional) mechanisms behind Dutch disease symptoms*. The overview of recent literature along the main strands of research attempting to explain cross-regional productivity shifts is carried out to connect the Dutch disease literature with broader theoretical frameworks of productivity spillovers, economic growth, cross-sectoral shifts and regional variations. Based on the expanded framework, the secondary research objective is to develop multivariate time-series analysis methodology tailored for evaluation of the cross-regional and spatial channels that accompany a resource boom period. Through this methodology, the research is aimed at *decoupling indirect and direct productivity spillovers across sectors and spatial (cross-regional) channels of productivity shifts.* Using the case of Canadian economy, the contributory component of the learning-by-doing mechanisms (indirect spillover) and active tertiarization (direct spillover) are estimated.

Empirical part of the study addresses *whether there is evidence for the persistence of spatial Dutch disease in Canadian economy and what are its mechanisms in terms of direction (spatial and sectoral) and magnitude.* Definition 'spatial Dutch disease' implies the mechanism whereby the resource-induced productivity growth in a resource-abundant region creates upward pressure on income and commodity prices in other regions through resource movement, spending and active tertiarization effects. This eventually leads to unsustainable economic growth and aggravation of regional disparities. In other words, it mirrors cross-sectoral productivity shift stylized as classical Dutch disease model at the scale of cross-regional variations.

3. Literature Review

3.1 Regional Economic Effects of Resource Booms

The current thesis relies on the previous research focused on studying effects of exogenous factors – resource explorations, global activity shifts – on regional economies. Foremost, as noted in the research background section, there has been limited previous studies on *testing effects of Dutch disease with the regional-level context*. Recent studies by Raveh (2012), Papyrakis & Raveh (2014) employ general equilibrium model to explain inflation rate through capital and labor movement accumulates. The study tests for a particular form of Dutch disease referred to as 'Alberta effect', which presumes capital attraction boost that follows a resource boom as a result of tax burden amelioration on the capital-intensive industries (Papyrakis & Raveh, 2014). Alcott & Keniston (2017) employ spatial equilibrium model to explore the coexistence of agglomeration and learning-by-doing mechanisms during periods of resource booms and busts. Employing the case of Canadian provinces, Beine et al. (2015) establishes the magnitude of mitigation effect that different types of human capital movements produce on Dutch disease symptoms. These studies represent the first attempts to bring Dutch disease model to the lower level of aggregation and indicate that expanded analytical frameworks might have to benefit both Dutch disease understanding and economic growth theory (Alcott & Kenistion, 2017).

There has been a wider discussion of regional economic effects within the broader branch of research – *exploration of 'natural resource curse' phenomena* (long-term negative effects of the resource exploration over the economic growth). This strand of research has significantly extended over the last years with the growing policy interest in strengthening resilience of regional economies (Boschma, 2015; Simmie & Martin, 2010). Several important causalities found are relevant to the current research. For instance, Black et al. (2005) decompose productivity spillover generated by booms in coal mining industry of Appalachia. The study ascertains that the largest spillover effect was accrued by construction industry, whereas traditional manufacturing was not affected at all (Black et al., 2015). Among the most stated methodological problems exhibited in this research area are sensitivity of the cross-country evidence on resource curse to observation period and countries being tested (van der Ploeg, 2011), endogeneity bias (Van der Ploeg & Venables, 2013) as well as ambiguities in definition of parameters (Allcott & Keniston, 2017). Therefore, exploiting cross-regional variations that would minimize macroeconomic noise is a research direction that could address these problems.

One of the slowing-down mechanisms commonly discussed in the literature establishes connection between *resource booms and regional labor market shocks* (Marchand, 2012; Sachs & Warner, 1999; Weinstein, 2014). These studies are aimed at estimating supply-demand models to model employment and income shifts. However, the major gap in this research area is that it offers limited explanation of the determiners of these shifts. The persistence of labor market shocks generated by the resource boom is reinforced by studies showing that resource-intensive sectors are characterized by higher absorptive capacity (Brunswicker & Vahnavarbeke, 2015). At the same time, the number of high-skilled jobs created in these sectors is disproportionately small compared to the manufacturing sectors. This in turn creates limited human capital movement across regions despite the gap in wages (Black et al., 2015). Marchand (2012) explored that productivity gaps that are generated by the boom-induced demand shocks are significant determinants of the labor market dynamics both in energy and non-energy sectors. Even though there has been a considerable research interest in explaining cross-country and urban-rural labor movements, Van Oort et al. (2015) indicates the lack of research on such phenomena between regions with different industrial composition.

In relation to this aspect, the tendency to employ two-sector models distinguishing between two conditional 'sectors' based on the export orientation or tradability, which presumes that the influence of spatial context is negligible, might explain lack of interest in regional dimension (Van der Ploeg & Venables, 2013). Thus, the recent research in the domain builds on two-speed economy model of economic growth, which assumes two separate 'corridors' of economic growth – 'non-tradable' sector' growing at a faster pace than 'tradable' (Bjornland & Thorsrud, 2016). Therefore, it would be beneficial for further research to adapt more case-specific sectoral decompositions. Research objectives and country context might make the dual model of 'tradable' and 'non-tradable' sectors less relevant. For instance, the windfall effect from the energy sector to the services sector in cases of post-industrialized countries might be of lower interest than that to traditional manufacturing. Further, decoupling factors behind tertiarization in post-industrialized economies could be more challenging.

3.2 Productivity Shifts and Economic Growth

Changes in productivity levels across sectors has been widely discussed in the economic growth literature from temporal perspective (Baily et al., 2001; Faderberg, 2003), as well as from the perspectives of regional economy (Andersson & Lööf, 2011; Lundquist et al., 2017) and agglomeration processes (Combes et al., 2012). From the temporal perspective, the processes of convergence and divergence across sectors have been incorporated within different paradigms that involve cyclical representations of economic growth. Based on the neo-Schumpeterian tradition, numerous studies touched upon cross-sectoral output differences through stylized models of economic growth such as economic cycles and technological shifts (Faderberg, 2003). Extensive literature in this direction indicates that the reoccurring economic cycles are characterized by specific patterns in resources distribution across sectors, mechanisms and intensity of spillovers (Funke & Niebuhr, 2005; Kose & Prasad, 2012), lag effects between industrial and institutional change, wage and prices structures. Over the last years, the growing interest has been attributed to applying advanced time series analysis techniques to identify or predict timing of cross-sectoral lags (Carlsson et al., 2016). Furthermore, it is indicated that preconditions of the growth in the booming sector play the vital role in determining the direction and significance of its effect over the dynamics of other sectors.

The growth of aggregated labor productivity depends both on productivity within distinct industries and on redistribution of labor between sectors with different productivity. Respective intra-industry and relocation components of the aggregate labor productivity have different underlying mechanisms (Carlsson et al., 2016; Combes et al., 2012) and therefore different response to external shocks. The former is associated with accumulation of human capital, intangible assets and technological processes, while the latter depends on the structural changes in the economy taking place in the economy that are boosted both from demand and supply sides (Baily et al, 2001; Lundquist et al., 2017). It is therefore one of the central research problems in the domain to decompose intra-regional and inter-regional components, as well as to conceptualize the importance of direct spillovers within the latter. Synthesizing spatial and sectoral outcomes of adjustment to external shocks is another research problem that indicates the need for expanding current frameworks to 'spatialize' structural shifts.

In contrast to regional economic models and productivity shift theories that widely employ the concept of geographic spillovers, the Dutch disease model incorporates the resource movement and spending effects (Corden & Neary, 1982). Resource windfalls as a result of real exchange rate appreciation might partly explain negative externalities as defined by Boschma (2015). Considering the case of Alberta province, Raveh (2012) analysed two-region resource model showing that low factor mobility costs bring about a fiscal advantage for a resource-abundant region ('Alberta effect') reversing Dutch disease symptoms. Accounting for spatiality of such effects and factors behind regional discrepancies could expand applicability of such model. Addressing this research problem is possible through decoupling learning-by-doing mechanisms and indirect productivity spillovers.

3.3 Methodological Approaches and Problems

Based on review of the Dutch disease literature and research area concerned with productivity shifts, the range of methodological problems that impede the expansion of research frameworks could be identified (following Allcott & Keniston, 2017; Bjornland & Thorsrud, 2016; Hutchison, 1994; Torvik, 2001; Sgherri & Galesi, 2009). First, approaches to investigation of interrelations across different sectors do not capture indirect spillover effects. The great bulk of the literature in both research areas reviewed rely on input-output tables. This methodology does not account for potential comovement of exogenous resources (international capital and labor inflows) across sectors. Further, it ignores the presence of common resource base that affects productivity shifts in different sectors. Second problem is associated with the complexity of quantifying agglomerative spillovers (Sgherri & Galesi, 2009). Methodologies based on vector autoregression model estimations are not capable of making estimations to explore these interrelations because of the failure to provide estimations with significantly elaborated level of classification ('classification bias') (Sgherri & Galesi, 2009).

To address the aforementioned problems, structural demand-supply modelling approaches were incorporated in the recent research. The number of studies suggested relevance of supplanting two-sector output models with multiple general equilibrium models to decompose factors of economic growth (Algieri et al., 2013; Kaplan, 2015). Dulger et al. (2013) extended the standard framework of the Dutch disease test by conducting Gregory-Hansen cointegration analysis with structural breaks, which allows to identify endogenous shifts in trend or regime of the long-run equilibrium. Recent studies also suggested applicability of such a framework to explore emergence of regional productivity gaps (Herrerias et al., 2013). Bjornland & Thorsrund (2016), testing for symptoms of Dutch disease in Norway and Australia, introduced the Bayesian dynamic factor modelling framework, which involves estimation of separate activity factors for booming and non-booming sectors. The framework has proven to be effective in separating indirect spillover and comovement effects (Bjornland & Thorsrund, 2016).

Further, developed analytical frameworks lack a comprehensive mechanism to account for spatiality of effects. Attempts to integrate methods of spatial econometric have been made to address this component. For instance, Rej & Montouri (1999) tested income convergence across regions of the US using spatial dependence and spatial error models. Accounting for spatial error autocorrelation contradicted previous research that found structural break in the convergence process (Rej & Montouri, 2009). In more recent research, Dall'Erba & Le Gallo (2008) estimated the dual model distinguishing between an external shock (EU structural funds) and the process of regional convergence. The traditional convergence analysis framework was controlled for spatial error autocorrelation and spatial heterogeneity in macroeconomic indicators to capture spatial diffusion of the shock effect (Dall'Erba & Le Gallo, 2008). Introduction of spatial equilibrium models revived interest in application of spatial econometrics in the field. Spatial equilibrium model solves contemporaneous equilibria of the number of regional markets assuming transportation costs differentials between regions (Maeda et al., 2005). Thus, evaluating Dutch disease effects associated with resource booms in the US, Allcott & Keniston (2017) applied Rosen-Roback equilibrium model, which is based on assumption of imperfectly-mobile labor across regions. The model disentangles learning-by-doing and agglomeration effects through allowing regional productivity to be designated both by lagged employment and by population in the region (Allcott & Keniston, 2017).

4. Methodology and Data Sources

4.1 Analytical Framework

The current thesis employs a two-stage methodology to test for symptoms of Dutch disease in Canadian economy. At the first stage, *country-level* symptoms are estimated using expanded Balassa-Samuelson framework. Thus, long-run equilibrium for real exchange rate dynamics is estimated to identify whether *(1) oil prices and (2) productivity gap between energy and non-energy sectors* are significant predeterminants of real exchange rate appreciation when controlled for real and monetary shocks. This test is complemented by the estimation of sector-output equations using cointegration analysis with structural breaks, which would enable to accurately test for the third symptom of the Dutch disease (upward pressure on commodity prices in non-energy sector are induced by volatility in oil prices).

At the second stage, testing is carried out for *cross-provincial level*. First, multivariate long-run equilibrium is estimated to explore cross-regional windfall effects. Second, dynamic factor modelling is carried out to decompose productivity spillovers across regions. The overall framework and methods of estimation are summarized on the Table 2.

Table 2: Methodology overview

Stage	Hypothesis Tested	Method
Country level		
1.1	Oil prices increase leads to real exchange rate appreciation when controlled for real and monetary shocks	VECM-based cointegration analysis
1.2	Productivity gap (energy sector / other manufacturing sectors) leads to RER appreciation	
1.3	Labor productivity growth and oil prices have negative impact on the output (energy sector / other manufacturing sectors)	Sector output equations model estimated with Gregory-Hansen test
Provincial level		
2.1	Energy sector has a direct productivity spillover over other manufacturing sectors and service sectors	VECM-based cointegration analysis
2.2	Oil prices and labor productivity growth in resource-abundant regions are significant determinants of productivity gap between regions	Bayesian dynamic factor model

Data sources for each variable are reported in Appendix A. The period of observation chosen is 1999Q1:2014Q4, which is justified by the need to take into account all the periods of economic transformation since the period of increased activity in the energy sector and to avoid macroeconomic disruption caused by the 1998 crisis. The industrial mix of interest 'other manufacturing sectors' represent the set of the fastest growing industries of manufacturing sector that have low common base and sectoral resource movement with oil and gas sector (Appendix B).

4.2 Estimation of Long-Run Equilibrium Equations

The long-run relationship between the components explaining the real effective exchange rate equation appreciation is estimated in line with expanded Balassa-Samuelsson effect model. The dependent variable, real exchange rate is designated as Canadian-dollar effective exchange rate index (CERI), calculated as a weighted average of bilateral exchange rates with the currencies of 7 major trading partners. In consistency with previous research and taking into account Canadian context, government explanatory component for real exchange rate dynamics is defined as government expenditures as a share of GDP, which is the more appropriate proxy for this case, considering high-level and decentralized fiscal system. As the measure of exogenous factor inducing the boom in energy sector, WTI spot prices on crude oil index is used. This is attributed to two facts (1) strong correlation between WTI and real prices on natural gas (2) WTI gives the most accurate approximation of oil and gas prices for North American market. Monetary component is defined through net interest rate to reflect direct interventions of the Bank of Canada. Analytical specification of the long-run equilibrium (**country-level**);

Real exchange rate (CERI) = f (α + Oil Prices + Productivity gap + Government + GDP + Interest Rate + ε), *(1)*

whereas, *Oil prices* – Dutch disease proxy, WTI spot prices on crude oil;
Productivity gap – labor productivity gap between energy and other manufacturing sectors.
Government – government expenditure as a share of GDP, consolidated government sectors;
GDP – gross domestic product at market prices;
Interest rate – net interest rate calculated as overnight money market financing, 7-day averages.

For the **provincial-level model**, *Reg productivity gap* is expressed as a labor productivity gap between provinces (set of energy-producing provinces vs other provinces); *real* *macroeconomic shock* is expressed as gross regional product; *government component* as a share of government expenditures to gross region product.

$$Real\ exchange\ rate\ (CERI) = f\,(\alpha + Oil\ Prices + Reg\ productivity\ gap + Reg\ government + GRP + Interest\ Rate + \varepsilon) \qquad (2)$$

First two symptoms, which are represented by basic precondition of national-level Dutch disease and Balassa-Samuelson hypothesis, are tested based on the long-run equilibrium model estimation.

Symptom 1: *whether the increase in oil prices leads to real exchange rate appreciation when controlled for real and monetary shocks*. Testing symptom 1 is aimed at identifying evident disease symptoms at the national-economy level.

Symptom 2: *increase in productivity gap between the energy sector and other manufacturing sectors significantly determines appreciation of real exchange rate*. Evaluating this symptom enables inferring the direction of combined effects of Dutch disease over the wages and prices in the economy.

To estimate the long-run equilibrium equations (1), Johansen cointegration analysis is carried out. First, preliminary tests for unit roots are carried out and the order of integration is identified (Augmented Dickey-Fuller test, in levels and in differences). Second, specifications of the VECM model are identified based on Akaike information criteria (AIC), Johansen maximum likelihood analysis. Third, the model is estimated and corresponding tests evaluating residuals of the model are carried out. The procedure is carried out two times – for national and provincial levels of aggregation with corresponding adjustments to the specification.

4.3 Sector Output Equations. Cointegration Analysis with Structural Breaks

Symptom 3: *aggregate productivity growth and oil prices have negative impact on the output ratio between the energy and other manufacturing sectors*. The conclusions about the persistence of the symptom are made adopting a multivariate framework testing cointegrating relationships with structural breaks. This framework is employed to get away from the trivial task of assessing single-equation approach (following Algieri, 2011; Dulger et al., 2013). The approach controls for endogenous structural breaks that could be present during the period of observation (Ho: no cointegration; H1: cointegration with a shift in level, trend, regime at certain breakpoint). Presuming the presence of different regimes endogenously to the model is particularly relevant to the given research task given that the Dutch disease mechanism involves abrupt changes in resources distribution. Research expectation is that the structural break occurs following the financial crisis 2008.

The analytical specification of the sector output equation is specified as follows;

$$Output_{energy\ sector} / Output_{other} = f(PROD, PrOil), \text{ structural break;}$$

whereas PROD – cross-sectoral labor productivity gap, PrOIL – exogenous factor, prices on oil.

Assuming a *structural break* and ascribing different ranks to series allow to more accurately single out the cross-causality interrelations. Furthermore, cointegration analysis with structural breaks allows for distinguishing between casual and non-casual components among long-run dynamics multipliers.

Cointegration analysis with structural breaks is carried out using Gregory-Hansen test (based on Gregory & Hansen, 1996). Thus, in correspondence to the general procedure of Gregory-Hansen test, three models that are based on assumption of the endogeneity of different types of breaks within cointegration vector are estimated:

(1) Cointegration test with a break in the constant term – break in level model

(2) Cointegration test with a break in the constant and the slope – break in regime model

(3) Cointegration test with a break in the constant, the slope and the trend – regime-trend break model.

In all models, lagging method is based on the Akaike Information Criteria value minimization. Following specification of appropriate model, the null hypothesis of no cointegration is estimated. If the final specification found statistically significant, corresponding multivariate regression is estimated. The following hypotheses are tested within this model;

(1) The Dutch disease mechanism presumes that the productivity growth reflects active labor mobility effect, hence – the higher productivity growth, the lower the output ratio between the energy sector and other manufacturing sectors. Productivity gap (between sector in the (1)

specification and between regions in (2) specification) is expected to be significant within the model and reflect a negative causality with output gap to validate the symptom.

(2) Under the Dutch disease scenario, oil prices drive factor prices in the non-booming sectors; thus, LN PrOil is expected to be negative. Further, differences between the results produced by the estimations with different breaks are estimated and explained.

4.4 Bayesian Dynamic Factor Model

Following the identified gaps in standard methodological approaches (see 2.1), the current thesis employs dynamic factor modelling as a framework for cross-sectoral variances' estimation at cross-provincial level of aggregation. The use of this approach instead of a traditional two-sectoral model benefits the current research in a number of ways. In line with Forni & Gambetti (2010), this method is based on a more parsimonious representation of comovement effects. In the dynamic factor model, external shocks are accounted as observable, while intra-sectoral shocks are considered as unobservable, which enables endogenous separation of learning-by-doing mechanism and indirect spillovers (Forni & Gambetti, 2010). Further, traditional two-sector models rely on theoretical classifications to identify which sectors are more exposed to external shocks and which are less (i.e. presuming two sectors of economy – tradable and non-tradable). Dynamic factor modelling allows to endogenously determine the level of exposure experienced by different sectors of economy to external shocks (Forni et al., 2015). Spatial Dutch disease mechanism hypothesized in the current thesis – cross-regional variance as a result of external shock – presumes that it is important to take into account variance of exposure of both regions and sectors to external shocks.

Additionally, traditional frameworks concerned with cross-sectoral dynamics rely on input-output estimations across sets of sectors. Since our focus is on cross-sectoral variance across regions, which implies data-heavy estimations, application of such a method would involve running separate estimations for each of the regions, which would not fit the research scope and impair interpretability of results. Particularly, this would not allow us to make any conclusions about the magnitude of external shock influence in inter-regional dynamics, while our framework presumes that it is *an external shock (oil prices) that drives regional discrepancies.* The Bayesian dynamic factor model applied considers four factors:

1. *Oil prices* – WTI index of prices on crude oil as an approximation of commodity price dynamics in the energy sector.

2. *Energy production component* – change in energy-sector production, the impulse to the given regional economy produced by the accumulated growth in oil and gas industry.

3. *Regional growth component* – accumulated change in activities not related to oil and gas production in the given region.

4. *External demand component* – approximation of the change in demand on the production of the given sector outside Canadian economy. Considering importance of the US market dynamics, the data on Canadian-US trade dynamics across different sectors is used as an approximation.

Oil prices and external demand component are accounted as observable variables, regional growth and energy production component are unobservable in this model. Distinguishing between energy production component and regional growth (non-energy activities) enables decoupling learning-by-doing mechanism from other cross-regional spillovers. In its turn, introducing external demand component allows to capture the shift in prices and wages induced by the change in foreign demand on the production. This component is restricted to respond to the oil prices shock with a lag in consistency with Bjornland & Thorsrud (2016).

Estimation procedure follows approach suggested by Barker & Link (2013) and the method employed by Deryugina & Ponomarenko (2015). First, the benchmark model is estimated using Johansen maximum likelihood testing and results are juxtaposed the output of a simple univariate model. The dynamic factor model is analytically specified as;

$$PRGAP = f\,(PrOil + EPC + RGC + EDC + \varepsilon),\ \text{whereby}$$

PRGAP - productivity gap (oil-producing provinces / other provinces)

PROIL - oil prices

EPC - energy production component (oil-producing provinces / other provinces)

RGC - regional growth component (oil-producing provinces / other provinces)

EDC - external demand component calculated per each sector (oil-producing provinces / other provinces).

Oil-producing regions – Alberta, Saskatchewan, British Columbia are selected based on the data on business activities per region (Appendix B). First, Bayesian vector error correction model is estimated to assess dynamic relationships between observable and unobservable components of equation. Simulation is done using one-procedure Markov Chain Monte Carlo technique (number of iterations; 12500). Second, forecasting model for the first differences of time series is estimated to approximate the trend and cycle (in this model, the trend is defined as a long-horizon conditional expectation). Third, the identification scheme and forecast error restrictions are specified so that the model's trend and cycle reflect the structural shocks by correspondent unobservable components. Lastly, variance composition of the regional productivity gap is carried out.

5. Results

5.1 Testing for Dutch Disease Symptoms at National Level

The output for vector error correction model estimation to test for national-level Dutch disease symptoms is presented on Table 3. According to the results of Johansen maximum likelihood test, the model includes at least 2 cointegrated relationships at the 5 per cent confidentiality level (preliminary unit root test results are reported in Appendix D). Based on the results, the long-run equilibrium model describing the real exchange rate change is specified as; *ln (real exchange rate) = 21.52 + 0.244 ln (GDP) – 0.928 ln (PROD) + 2.671 ln (IR) + 0.695 Ln (GOV) – 0.049 Ln (PrOil).* Therefore, while controlled for real and monetary shocks, price of oil is negatively related to the real effective exchange rate of Canadian dollar. Hence, *the presence of the symptom 1 of Dutch disease at national level of aggregation can be rejected,* which resonates with expectations of the research. These findings are in concordance with the recent research evidence on the weak integration of oil prices into the Canadian dollar exchange rate (Issa, Lafrance & Murray, 2008; The Canadian Chamber of Commerce, 2012).

Table 3. VECM model (1) output

Cointegration Vector *B*	Coefficient	P>z
Ln (REER)	1.000	
Ln (GDP)	0.244	(0.007)
Ln (RPROD)	-0.928	(0.003)
Ln (IR)	2.671	(0.000)
Ln (GOV)	0.695	(0.251)
Ln (PrOIL)	-0.049	(0.000)
Const	21.52	(0.001)
α, Speed of adjustment		
Ln (RER)	0.062	(0.191)
Ln(GDP)	0.006	(0.510)
Ln(RPROD)	-0.008	(0.742)
Ln(IR)	0.021	(0.819)
Ln(GOV)	-0.519	(0.000)
Ln(PrOIL)	0.627	(0.006)

Furthermore, based on the vector error correction model estimation, the real exchange appreciation is not fuelled by a productivity gap between the energy sector and other manufacturing sectors. In contrary, negative effect of the increase in labor productivity gap over real exchange rate is ascertained. Therefore, *the symptom 2 of Dutch disease can be rejected* for the model accounting for national-level of aggregation. While this testing does not provide enough evidence on the magnitude and direction of productivity spillovers, it could be inferred that there is insignificant upward pressure of the energy sector over other manufacturing sectors. Other notable finding is that the government expenditures as a share of gross domestic product is found to be a statistically insignificant determinant of the real exchange rate appreciation in contrast to previous case studies focusing on developed countries (Larsen 2006; Rodrik, 2008). This implies that the Canadian dollar rate fluctuations are not determined by top-down reallocation of resource revenues through the government expenditures.

Examining speed of adjustment coefficients within vector error correction model-based framework enables to evaluate the pace of short-run convergence between the variables. Only for *oil prices* and *government expenditures as share of GDP the* speed of adjustment is found to be statistically significant. That is, the negative adjustment by 51.9 per cent per 1 quarter is required to adjust back the long-run equilibrium under the external shock, while the positive adjustment by 62,7 per cent adjustment in oil prices is sufficient to put maintain the long-run equilibrium. Such a high input required from the side of oil prices to adjust real exchange rate rejects the symptom 1 of Dutch disease.

Table 4. Gregory-Hansen cointegration test, national-level data

Specification	Lags	ADF statistics (critical, 5%)	Zt statistics (critical, 5%)	Za statistics (critical, 5%)	Breakpoint
Break in Level	1	-3.82 (-4.92)	-3.83 (-4.92)	-19.16 (-46.98)	2002q3
Break in Regime	1	-4.94 (-5.5)	-4.98 (-5.5)	-35.06 (-58.33)	2006q4
Break in Regime and Trend	0	-6.11 (-5.96)	-6.22 (-5.96)	-46.64 (-68.43)	2008q4

Results of sector-output equations estimated with Gregory-Hansen cointegration test are reported in Table 4. Estimations presuming breaks in level, regime, regime and trend are carried out. Augmented-Dickey Fuller, Zivot, and Zivot and Andrews statistics are estimated for each of the specifications (Ho – no cointegration is rejected if |Test Statistics|<|Critical Value|). Following Gregory & Hansen (1996), if cointegration is present according to at least one of the tests, the model indicates the presence of the breakpoint. The structural breakpoint is assumed endogenously and points to the quarter following the Financial crisis (2008q4) in consistency with expectations of the research.

Therefore, following Gregory-Hansen test procedure, regression model with dummy variable defining breakpoint in regime and trend and 0 lags is estimated. Based on the output of this model, we can *corroborate the presence of the symptom 3* of Dutch disease in Canadian economy. First, oil prices are found to statistically significant in determining gap in the output between energy sector and the set of non-energy sectors. Second, the increase in output of the energy sector and overall productivity are in inverse relationship, while the growth in the output of non-energy sectors entail the growth in overall productivity. This indicates the presence of resource movement effect driven by the oil prices and having negative effect on the overall productivity.

Table 5. Regression model with break in regime and trend

Model	PROD before 2008q4	PROD after 2008q4	PrOIL before 2008q4	PrOIL after 2008q4
Output gap = (PROD, PrOIL), x=breakpoint, lags(0) regimetrend	- 0.057	0.96 (insignificant)	-0.71	-1.33

5.2 Provincial-Level Dutch Disease Testing. Spatial Dutch Disease Mechanisms

First, vector error correction model for provincial-level data is estimated in similarity to the national-level estimation but substituting the component of cross-sectoral productivity gap with cross-regional productivity gap. Cross-regional productivity gap is a ratio between accumulated labor productivity indicators for energy-producing sectors and that for other sectors. 3 cointegrated relationships are indicated based on Johansen maximum likelihood test.

Table 6. VECM output for provincial-level estimations

Cointegration Vector *B*	Coefficient	P>z
Ln (REER)	1.000	
Ln (GDP)	-0.014	(0.115)
Ln (RPROD)	-0.011	(0.009)
Ln (IR)	0.997	(0.006)
Ln (GOV)	0.695	(0.278)
Ln (PrOIL)	-0.031	(0.003)
Const	18.75	(0.002)

Our hypothesis states that productivity gap across regions is a significant determinant of real exchange rate appreciation when controlled for monetary and real shocks, which is validated at 5 per cent confidentiality level. This reflects the discrepancy in the export orientation of the industrial profile across provinces. Further, it indicates that the energy sector specialization makes economies of the provinces (Alberta, Saskatchewan, British Columbia) more exposed to external shocks.

The results of the variance decomposition based on Bayesian vector error correction model are reported in Table 7. The estimation is done at h = 4 and h= 8 as well as compared to the model with unconditional variance. The output represents contemporaneous contribution of the given component into the variance of the observable parameter (regional productivity gap) over the lag (4 and 8 quarters for productivity gap estimation; 8 quarters for adjustment estimations). Furthermore, decomposition of output and employment variance in non-energy and energy sectors is carried out at $h = 8$ for the endogenously identified period of the largest increase in oil price. Identification of period of resource boom is done based on the Gregory-Hansen procedure for vector error correction model with endogenously presumed breakpoint in trend. For this test, the period around the financial crisis 2008 (from the 2006q4 to 2009q1) is excluded from the estimation, as the increase in oil prices was followed by rapid shrinkage, both in oil prices and in macroeconomic parameters, so it could not be used as a case period for estimating resource boom spillovers.

Table 7. Bayesian VECM Output. Variance decomposition for provincial-level estimations

Component	Oil prices		EPC		RGC		EDC	
Lag	4	8	4	8	4	8	4	8
Productivity Gap (oil-producing provinces vs others)	0.24	0.13	0.17	0.22	0.05	0.15	0.12	0.16
Regional Productivity Gap (Alberta vs others)	0.3	0.27	0.20	0.24	0.04	0.09	0.09	0.1
Adjustment	Oil prices		EPC		RGC		EDC	
Regional gaps / lag	8		8		8		8	
Output, non-energy sectors	0.01		0.07		0.25		0.21	
Employment, nonenergy sectors	0.09		0.08		0.29		0.00	
Output, energy sector	0.25		0.19		0.00		0.18	
Employment, energy sector	0.11		0.26		0.00		0.04	

The presence of the spatial Dutch disease is partly validated in this model. *Oil prices are identified to have a statistically significant relation to the regional productivity gap* explaining 24 and 13 per cent of the gap, lagged by 4 and 8 quarters respectively. On the other side, effect of the oil price shock on productivity gap is found to be relatively short-lived, which is in consistency with broader regional resilience literature. Energy production component explains larger part of the variance at 8-quarters lag, which indicates *the presence of the productivity spillovers from the energy sector of oil-exploring provinces to energy and related sectors of other provinces.* Notably, regional growth component explains negligible 5 per cent of the regional productivity gap in this model in 4-quarters lag.

Further, we control for potential distortion in this model decomposing the productivity gap between Alberta province (the province that has the largest total output in 'oil and gas exploration' national account). Comparing these two variance decompositions on importance of spatial effects. Thus, external demand component is found insignificant for Alberta vs others productivity gap indicates high level of integration in the energy sector – output and employment across different regions are affected equally by the shifts in the US market conjuncture. Another important observation is that oil prices explain large part of Alberta vs others productivity gap (39 per cent). In comparison to the studies on Alberta effect that decomposed the output gap between Alberta and other provinces (e.g. Beine et al, 2012; Raveh, 2013), the obtained indicator is slightly lower, which is attributed to the fact that in this model, external demand and oil prices are separated.

On the other side, no evidence is found that the variance in output in non-energy sectors is influenced by oil prices. On the other side, oil prices shock is ascertained to explain 29 per cent of the variance in 8 quarters after the largest oil price variation. The contribution of the external demand component exceeds that of energy production component by one third, reflecting that the dynamics of energy sector is more responsive to the US market dynamics rather than that of domestic consumers during the periods of resource activity shocks. Regional growth component, that is, dynamics of non-energy sectors, is found to be the only significant component explaining the employment gap across regions (31 and 27 per cent). Importantly, the variance in employment in the energy sector between two groups of regions is significantly, and with at a growing pace, caused by the change in energy growth component. This gives evidence to the active *relocation of resources from the energy sector to related ones (located in other regions than oil-exploring) following the oil price boom (learning-by-doing mechanism).* That is, the companies working in the sectors serving the oil and gas exploration directly benefit from the oil price shock. This finding is in consistency with assumptions of The Chamber of Commerce of Canada (2012), indicating that 255 companies contracted for oil sands explorations in Alberta are based in Ontario. The effect is also consistent with the evidence on growing trade activity between oil-exploring regions and Ontario (Statistics of Canada, 2017). The non-energy sector employment gap observable is slightly explained by the growth in energy growth component (8 per cent). This indicates that, *even if active tertiarization by labor movement from the energy sector of oil-exploring regions to non-energy sectors of core regions takes place, it is insignificant to explain the regional variance (active tertiarization)*. Therefore, regional disparities in wages, output, and employment across Canada are mostly ascribed to learning-by-doing mechanism rather than active tertiarization.

6. Findings and Conclusions

In this thesis, the approach to measure regional mechanisms behind Dutch disease is developed using multivariate time series techniques. Analytical framework developed expands the current literature in a number of ways. First, it represents the first attempt to model Dutch disease mechanisms' 'spatiality'. The model is based on an assumption that mechanisms behind regional discrepancies act in a same way as cross-regional variance under scenario of external shock (oil price increase). Second, approach developed relies on the synthesis of recent findings in the areas of Dutch disease and resource curse on the one side, and productivity shifts and spillovers, on another. This enables to further closing a theoretical gap between these research areas. Third, it is identified that studying Dutch disease on lower level of aggregations, i.e. regional data, may enrich understanding of latent cross-sectoral linkages. However, further research in this direction could be impeded by the lack of data on the necessary level of aggregation.

Furthermore, the use of Bayesian dynamic factor modelling – the technique commonly used in advanced time series analysis in predicting influence of structural shocks over exchange rates, prices – enabled to more accurately decouple cross-sectoral resource movement, spending, and active tertiarization effects. Particularly, development of the factor model whereby oil prices and external demand components are separated allows for taking more accurate control of the macroeconomic noise in contrast to previous Dutch disease modelling frameworks. In addition, dynamic factor model distinguishes between learning-by-doing mechanisms and active tertiarization enabling to explore the Dutch disease effects' direction in terms of regional and sectoral variance.

Empirical study was conducted testing national-level and provincial-level symptoms of Dutch disease using 1999Q1:2014Q4 sample period. First, the presence of Dutch disease at national level is tested using Johansen cointegration analysis with structural breaks. In consistency with research expectations, the basic precondition of Dutch disease persistence that *the increase in oil prices leads to real exchange rate appreciation when controlled for real and monetary shocks* was rejected (Symptom 1). This is reinforced both by long-term and short-term effects identified – in the long-run equilibrium, oil prices are found to be an insignificantly related to real exchange rate, while in the short run increase in oil prices of as high as 62.7 per cent over

1 quarter is required to adjust equilibrium. The primary effect of Dutch disease that holds that *the increase in productivity gap between the energy sector and other manufacturing sectors significantly determines real exchange rate appreciation* is also rejected based on Balassa-Samuelsson long run-equilibrium estimation. Negative effect of the increase in labor productivity gap over real exchange rate is identified in this model. However, the symptom 3 *(aggregate productivity growth and oil prices have negative impact on the output ratio between the energy and other manufacturing sectors)* was corroborated indicating unsustainability of the growth in manufacturing sectors' output; thus, giving basis for conducting test on the provincial-level.

Variance decomposition of the cross-regional indicators is carried out to test the presence of regional factor behind Dutch disease. It was found that *regional divergences between oil-exploring regions and other parts of Canada are significantly driven by the external shock (oil prices).* Furthermore, strong evidence of productivity spillovers between energy sectors of oil-exploring regions and sectors serving the energy sector in other regions is identified. On the other side, non-energy sector employment is slightly explained by the boost in oil and gas exploration. This corroborates that the direction of spillovers from 'oil and gas exploration' sector is *mostly driven by learning-by-doing mechanisms rather than by active tertiarization*. In the same time, the direction and magnitude of spillovers is more determined by external shocks rather than by geographical location of regions. Companies engaged into the sectors serving the oil and gas exploration and located in non-oil-exploring regions disproportionally benefit from the oil price shock. Understanding of these cross-sectoral effects might have policy implications; particularly, to support federal spending and regional support programmes. Moreover, these findings can be used for identification of growth-inducing effects at provincial levels. Last, these findings might advance development of macroeconomic instruments to mitigate Dutch disease effects, such as migration policies interventions, shifts in government spending allocations, and imposing different fiscal regimes across regions.

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Appendices

Appendix A: Variables and Data Sources

Variable	Definition	Unit	Source	Frequency,aggregation
Ln (REER)	Canadian-dollar effective exchange rate index (CERI), weighted average of bilateral exchange rates against the currencies of 7 major trading partners	Index (2010=base year)	Bank of Canada Parameter: V41498903	Quarterly, average Seasonally adjusted
Ln (PrOIL)	Global oil price based on WTI Crude	USD per barrel	International Monetary Fund	Quarterly, average adjusted by seasonal dummy variable model
Ln (PROD)	Average labor productivity by North American Classification System	Index (2010=base year)	Statistics Canada, CANSIM database, Table 383-0012	Quarterly, average Seasonally adjusted
Ln (RPROD)	Relative productivity (energy sector / fast-growing manufacturing sectors)	Index	Statistics Canada, CANSIM database, Table 383-0012	Quarterly, average Seasonally adjusted
Ln (GOV)	Government expenditure as a share of GDP, consolidated government sectors	%	Statistics Canada, CANSIM database, Table 385-0032	Quarterly, average Seasonally adjusted
Ln (NFA) (Net foreign assets)	Difference between net acquisition of foreign assets and net incurrence of foreign liabilities	Canadian dollars	Statistics Canada, CANSIM database, Table 376-0104	Quarterly, average Seasonally adjusted
Ln (GDP)	Gross domestic product at market prices	Canadian dollars	Statistics Canada, CANSIM database, Table 379-0028	Quarterly, average Seasonally adjusted
Ln (IR) (interest rate)	Overnight money market financing, 7-day averages	Index	Statistics Canada, CANSIM database, Table 176-0043	Quarterly, average Seasonally adjusted
Ln(OUT)	Ratio of the output in the energy sector to that in the fastest growing non-energy manufacturing sectors	Index	Statistics Canada, CANSIM database, Table 379-0031	Quarterly, average Seasonally adjusted
EPC	Energy production component – the ratio between accumulated output in sectors that are related to oil and gas exploration (relatedness is identified based on cross-sectoral trade data for national level)	Index	Statistics Canada, CANSIM database, Synthesis of tables	Quarterly, average Seasonally adjusted
RGC	Regional growth– the cross-regional ratio between accumulated output in sectors that are unrelated to oil and gas exploration	Index	Statistics Canada, CANSIM database, Synthesis of tables	Quarterly, average Seasonally adjusted
EDC	External demand component – the U.S.-Canada accumulated trade in a particular sector, quarterly approximation	Index	Export Development Canada - Database	Quarterly, average Seasonally adjusted

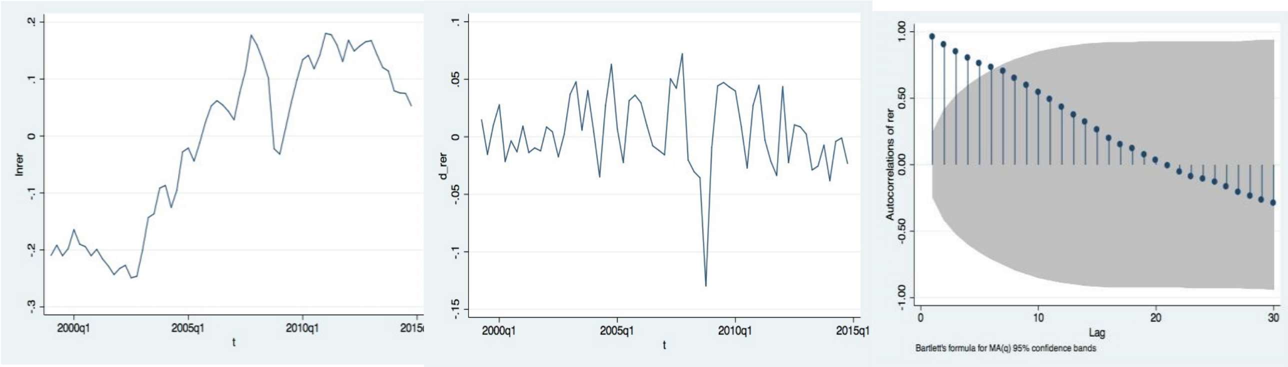
Appendix B: Classifications of Sectors and Regions

'Other Manufacturing Sectors'	Output (2013) in Canadian dollars, CANSIM database, 381-0031	Labor Productivity (2015); CANSIM database, 383-0033
Furniture and related products	10787.5	31.7
Electrical equipment, appliances and components	9759	60.2
Transportation Equipment	11439.1	68.5
Miscellaneous manufacturing	13627.3	34.9

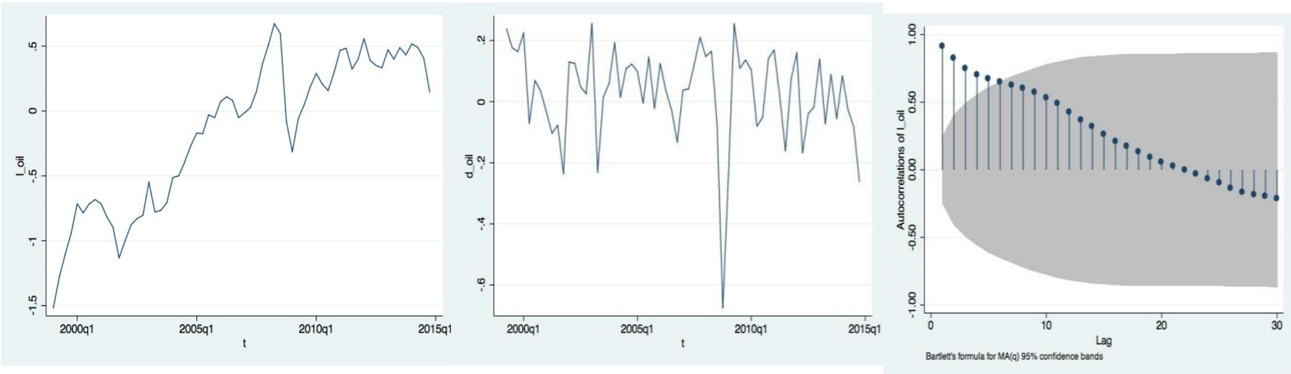
Provinces Classification	Output of oil and gas exploration industry (2013) in Canadian dollars, CANSIM database
'Oil Exploring Provinces'	
Alberta	619603.2
Saskatchewan	143532.6
British Columbia	379790.0
'Other Provinces'	
Ontario	856936.1
Quebec	30368.2
Newfoundland and Labrador	57242.5
New Brunswick	64869.8
Manitoba	107547.2
Northwest Territories	8551.4
Nunavut	4452.3
Yukon	4349.3
Nova Scotia	65333.1

Appendix C: Graphical Inspection of the Dataset

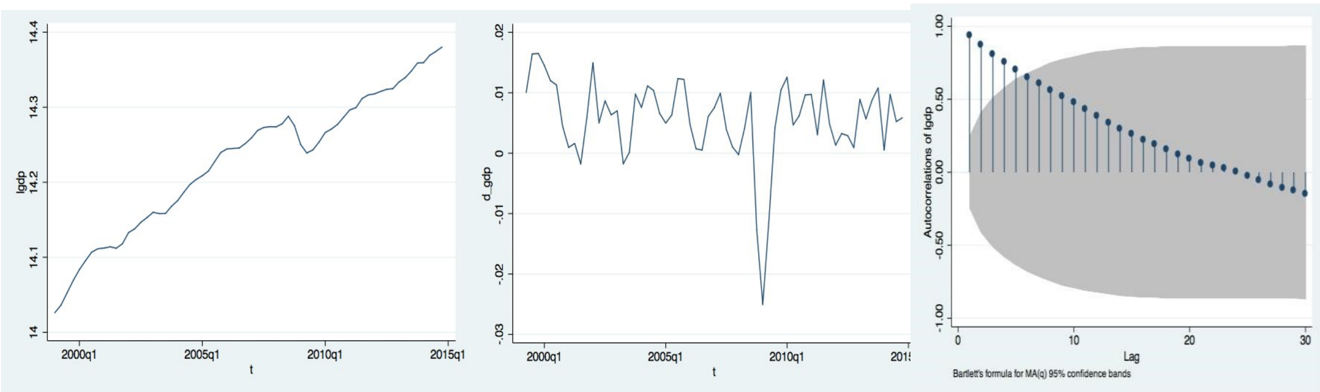
1. Real Effective Exchange Rate, CPI-based



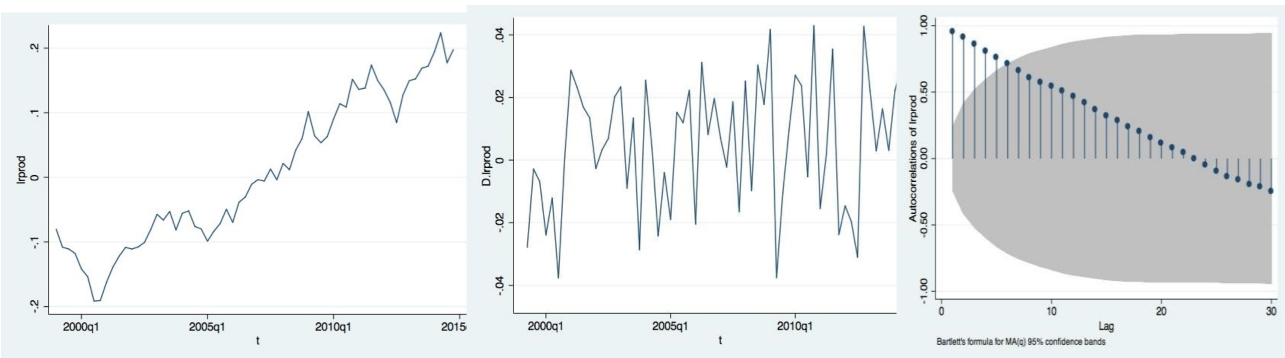
2. Oil Prices



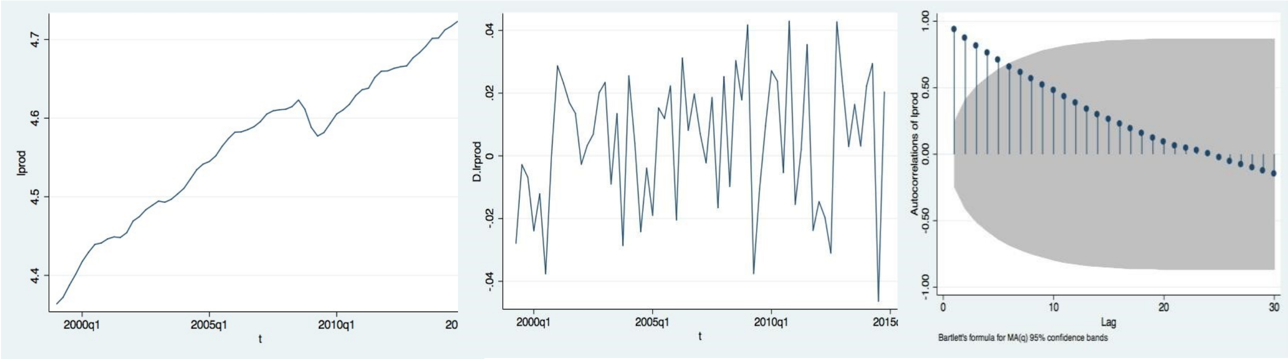
3. Gross Domestic Product



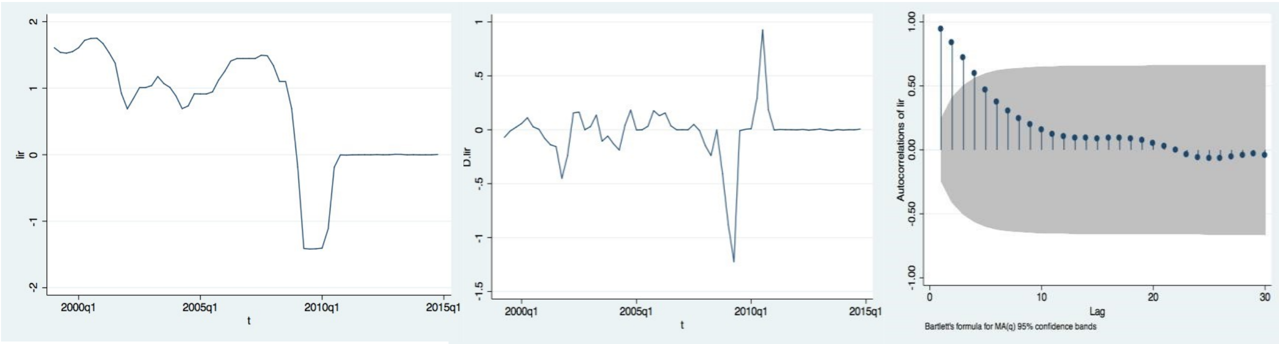
4. Sectoral Productivity Gap



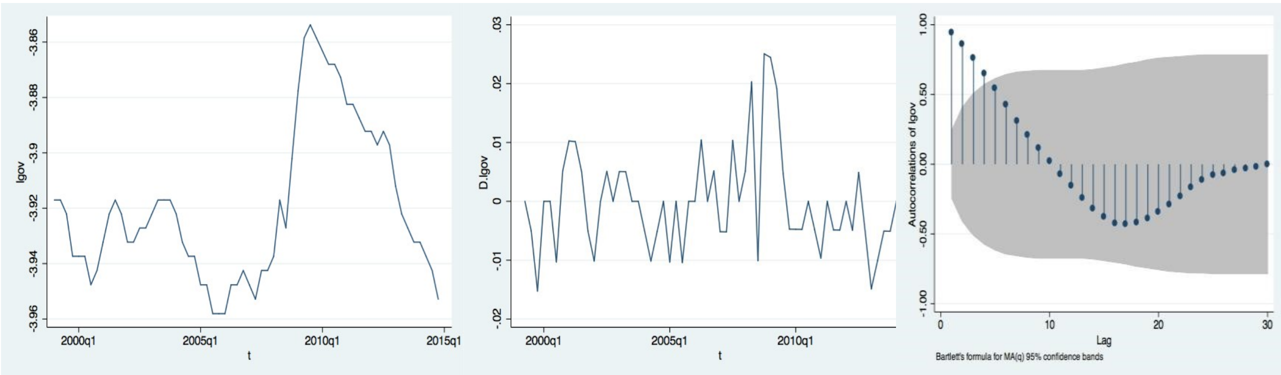
5. Regional Productivity Gap



6. Interest Rate



7. Government Expenditure



Appendix D: Unit Root Testing, VECM

Augmented Dickey-Fuller Test, in levels and differences

Variable	Lags	Specification	T-stat	5-%-critical
Ln (RER)	1	Trend Intercept	-1.966	-3.488
Diff.Rer	1	Trend Intercept	-5.329	-3.489
Ln(PrOIL)	1	Trend Intercept	-3.0	-3.488
Diff.Oil	3	Intercept	-4.80	-2.923
Ln(GDP)	2	Trend Intercept	-2.443	-3.489
Diff.GDP	1	Intercept	-4.278	-3.565
Ln(GOV)	1	Trend Intercept	-1.479	-2.920
Diff.Gov	1	Intercept	-3.704	-3.489
Ln(IR)	2	Trend Intercept	-2.818	-3.489
Diff.Ir	1	Trend Intercept	-4.390	-3.489
Ln(PROD)*	1	Trend Intercept	-2.411	-3.490
Diff.Prod	1	Intercept	-4.205	-2.923
Ln(RPROD)	2	Trend Intercept	-3.11	-3.488
Diff.RProd	1	Trend Intercept	-5.230	-3.489
Ln(OUT)*	1	Intercept	-1.954	-3.488
Diff.LnOut	2	Trend Intercept	-4.638	-3.490