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Innovation policy & labour productivity growth: Education, research & development, government effectiveness and business policy

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Innovation Policy & Labour Productivity Growth

Education, Research & Development, Government Effectiveness and Business Policy

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Abstract

This paper examines the relationship between labour productivity growth in non-traditional sectors and "innovation policy" for a cross-section of countries. Innovation policy is characterized by investments in tertiary education and research and development as a percentage of Gross Domestic Product (GDP), the freedom in the business environment, as well as overall government effectiveness. Our results confirm the economic convergence between richer and poorer countries. We could show a significant positive effect of the interaction between government effectiveness and government expenditures in tertiary education as a percent of GDP on labour productivity growth in non-traditional sectors. Also, for developing countries, a positive and significant relationship between the growth variable and effective research and development expenditures was observed. We could not uncover a relationship between other innovation policies and labour productivity growth. Non-traditional sector labour productivity growth in the oil rich Arabian Gulf countries was observed to be consistently slower than western countries. Higher oil prices appear to crowd-out innovation in oil-rich countries while stimulating innovation in oil importing countries.

Keywords: Innovation policy, labour productivity growth, technological change, government effectiveness, developing countries, Arabian Gulf countries.

JEL Classification: O2, O3, O38, O43, O47

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1. Introduction

In this work we analyse how individual innovation policies and their interactions influence innovation globally, in developed and developing countries. Growth literature moving beyond capital and labour introduces knowledge, technological change, and innovation as drivers of growth[1]. It discusses healthy institutions as necessary for technological change, and points towards innovation policy to nurture the institutions that promote knowledge production and technological progress. The lumping together of the factors that contribute to human capital, physical capital, and institutional capabilities has been considered as a common deficit in the literature. The need for deeper enquiry into the importance of complementarities in policies that go into affecting activities, capabilities and institutional arrangements has been emphasized (Easterly & Levine, 2001; Freeman, 2002; Aghion, et al., 2009). As such, "innovation policy" including, education policy, research and development (R&D) policy, business policy, and governance is considered.

While discussing education and R&D policy in the context of innovation and labour productivity growth there has been a debate whether higher education and R&D expenditures have higher returns for developed countries than developing countries (Krueger & Lindahl, 2001; Keller, 2006; Aghion & Durlauf, 2009). An important insight is that countries could be less efficient in the translation of innovation policies to productivity growth (Griffith, et al., 2004; Jo Ritzen, 2011; Loukil, 2014). In this paper we introduce the effectiveness of government in analysing the relation between labour productivity growth and innovation policy.

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[1] Solow's works, and studies by Denison, showed that something other than labour and capital was responsible for increasing growth rates in the US (Solow, 1957; Denison, 1963). Romer (1986) incorporated technology as an endogenous factor in constructing a model of increasing returns of technology and knowledge for long-run growth. Nelson and Winter's (1982) work on the evolutionary approach views the free market economic structure as continuously evolving with emphasis on the influence of institutions on economic activity.

We consider the different strategies that may be required to innovate under various conditions of development. We also provide a glimpse of labour productivity growth in relation to innovation policies in Arabian Gulf countries, that are characterised by a high share of natural resource rents in the economy.

Defining the ideal combination of institutions and policies that are important for innovation is a complex task. Considering that innovation based growth is less likely to reflect in traditional industries (Becheikh, et al., 2006), we proxy the dependent variable innovation for both developed and developing countries as the non-traditional sector labour productivity growth. That is labour productivity growth exclusive of natural resource rents and agricultural value added. Innovation policy is characterised by the interaction of expenditures on education with effectiveness of government, the interaction of expenditures on R&D with the effectiveness of government and business policy. Our identification strategy comprises five-year labour productivity growth rates regressed as a function of initial labour productivity, relevant innovation policy variables lagged by five years, control variables and dummy variables.

The literature focussing on growth and productivity impact of innovation polices related to education, R&D, business and governance is discussed in Section 2. Our identification strategy is drawn out in Section 0. The data are presented in Section 4. Results related to the effect of innovation policies in the global context, as well as for developed and developing countries are presented and discussed in Section 5. Finally, we discuss results, their policy implications, and present our concluding remarks in Section 6.

2. Innovation policies and the path towards successful innovation

The innovation literature is distributed between "narrow" and "broad" focus on innovation policies. In the "narrow" sense only formal R&D systems and organizations systematically active in knowledge generation and diffusion are the focus. An example of application of the systems of innovation framework in the former sense is World Bank Knowledge Assessment Methodology (Chen & Dahlman, 2005). However, systems of innovation in a narrow sense “leave significant elements of innovation-based economic performance unexplained” (Lundvall, 2007). In the “broad” sense the core knowledge producing and disseminating institutions are embedded in a wider socio-economic system and the relative success of innovation policies is a function of influences and linkages beyond these core institutions (Freeman, 2002; Soete, et al., 2010). Among the works that discuss new-to-the-world innovation in the latter sense Furman, Porter and Stern (2002) integrate ideas-driven growth theory, microeconomics-based models of national competitiveness and industrial clusters theory and considers R&D manpower, knowledge and technology base as important sources of innovation. Archibugi & Coco (2004) define innovation system through patents, publications, ICT, electricity consumption, and education.

Aghion et. al (2009) set out to estimate plausible causality of the effect of education on growth, using actual measures of investment in education. They question the adequacy of using lagged spending – in their previous work (Vandenbussch, et al., 2004) – as an instrument to overcomes biases caused by omitted variables such as institutions, especially in the case of small low variation data. They show that there are positive effects of exogenous increase in education expenditure related to four years' tertiary education in U.S. states close to the world frontier (Aghion, et al., 2009). Krueger and Lindahl (2001) find societal returns to schooling in terms of increased growth in cross-country analysis; the relationship is statistically significant and positively associated with subsequent growth for countries with the lowest level of initial education.

Faster growing countries in Asia have had higher expenditures on primary education. Keller (2006) suggests that inefficiencies in resource allocation of secondary and tertiary education expenditures may be the reason behind not obtaining positive significant results consistently for the effect of such investments on growth. In other studies, government expenditures on education relate positively to growth in developing countries (Bose, et al., 2007). Also, the inclusion of other policy variables in the studies, such as openness, public spending, and health variables results in a lower estimated impact of education on growth (Benos & Zotou, 2014). From these studies we conclude that education should be considered as a part of “broad” policies for innovation based growth.

Loayza et al. (2005) find that regulatory burden reduces growth. However, higher quality of institutional framework leads to the negative effects of excessive regulation on growth to be lessened. In a simple model Djankov et al. (2006) observe the effect of business regulations as represented by the doing business indicators while considering the effect of initial level of growth, and control variables and other determinants of growth that include corruption, law and order, the political system, primary and secondary school enrolment, and civil conflict. They find that going from the worst to the best quartile of business regulation shows a 2.3 percentage increase in annual growth rate. They also observe that the effects of improvement in primary and secondary education from worse to better quartiles of policy or output are significantly lower than the effects of business regulation on growth rate. Hanusch (2012) suggests that regulations related to credit, contract enforcement, costs, time, starting a business, registering property, and protection of investors within realm of business policies are statistically significantly related to economic growth.

Griffith and team (2004) find that R&D as represented by BERD is statistically and economically important in the catch-up process as well as for stimulating innovation directly and suggest that the social rate of return of R&D has been underestimated in the literature as many studies only focus on the United States. A look into cross-country labour productivity differences due to investment in R&D reveals that R&D investment has significant positive impact on productivity (Lichtenberg, 1993). Nadiri and Kim (1996) find rates of returns of domestic R&D expenditures to be in the range of 14 to 16% and adding the effect of spill-overs of international R&D spending for 6 advanced economies showed the returns to be 23 to 26% varying amongst the countries.

Hall, Mairesse, and Mohnen (2010) in their review of the econometric literature measuring the private and social returns to R&D find that the literature identifies private returns to R&D as strongly positive, social returns to be even greater and that most estimates for public-funded R&D are found to be less productive in terms of private returns. In many research avenues, the incentives to invest in R&D is determined on the basis of private returns and not social returns. As such it may be that developing countries are not able to achieve maximum potential in R&D due to inappropriate social policies (Griffith, et al., 2004).

Jalilian, Kirkpatrick and Parker (2007) find that there is strong causal link between government regulation, regulatory quality indices, and economic performance. Other cross-sectional studies also report causal effects of governance on long run income per capita, using instrumental variables (Kaufmann & Kraay, 2002). Also, the mechanism behind this causal link has been examined and one path through which government effectiveness improves economic performance is by creating a better investment environment (Kirkpatrick, et al., 2006). It is likely that government effectiveness translates into high economic growth not only through the path of providing a good investment environment but also by creating good environment for innovation policies to be effective.

The common theme that emerges from the literature is that innovation policies work in coherence with each other and have a combined and complementary effect on growth and productivity. The translation of policy to increased innovation must go through the governments' ability to effectively convert inputs of policy into labour productivity growth and in case of innovation in the non-traditional sector particularly.

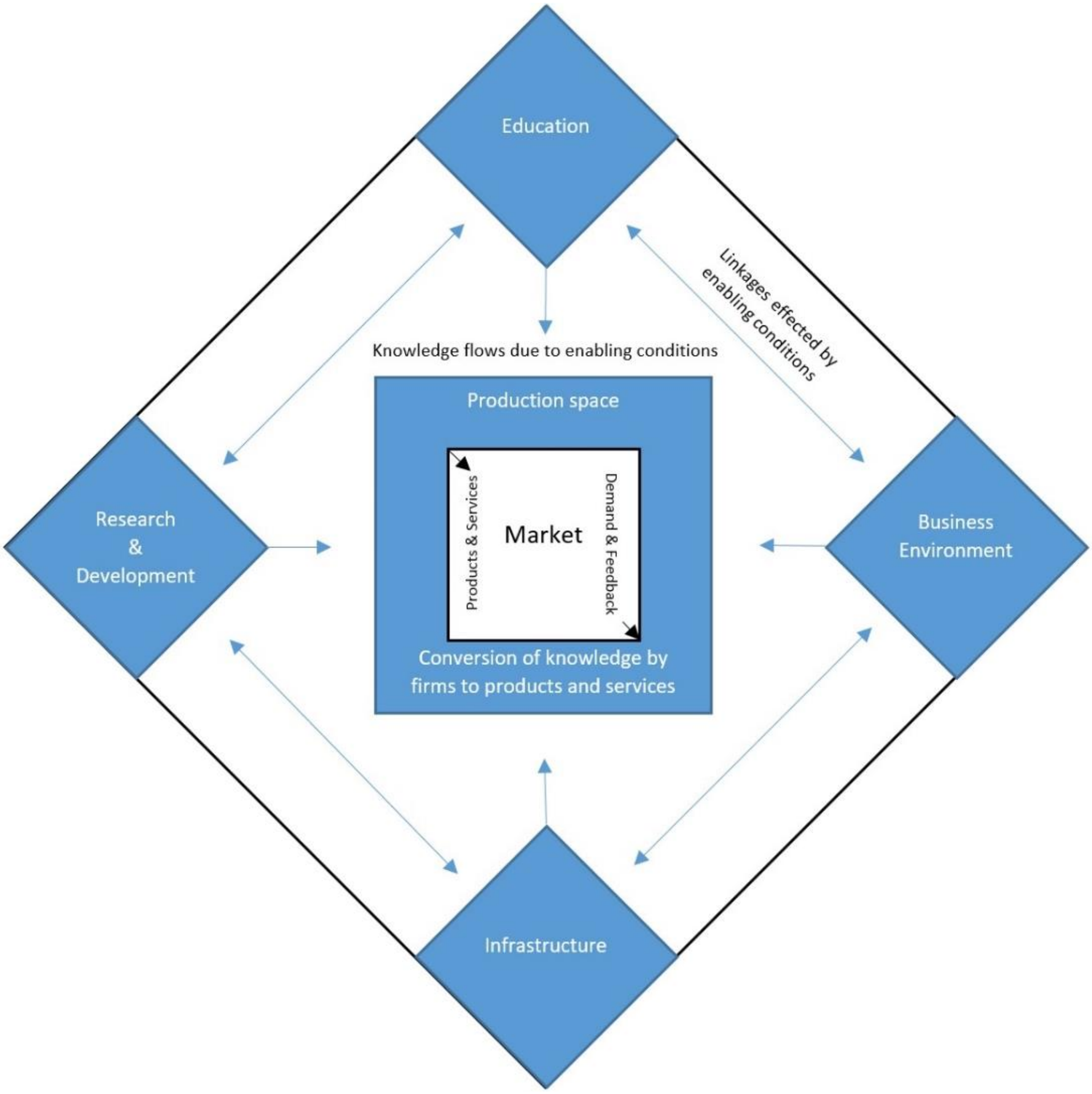

Figure 1 – Innovation Policy Framework Conditions

Figure 1 above represents our interpretation of how the flows of knowledge enable growth in innovation through increase in productivity in an economy. The innovation eco-system is thus arranged into conditions, linkages, the firms and the market itself. The change in state of these conditions is determined through natural transformation and policy. The education condition is affected by government policies as government financing of the tertiary education system, policies determining graduate ratios in science and technology fields, alignment to labour demand from market, university autonomy, and others. Similarly, research and development conditions are impacted by government expenditure on research and development, type of research grants, targeted scientific field grants, competitiveness of grants, intellectual property regime, and private sector research funding, and so forth. Business conditions are related to industrial policies, competition policy, entrepreneurship policy, taxation policy, financial policy, health of financial sector, availability of finance, and market access for firms that create new products or services. Infrastructure conditions include availability of ICTs, Transport, Energy, Standard-Setting, Metrology, Security, etcetera. Finally, it is considered that without efficient and effective linkages the production of knowledge as well as transfer of knowledge for creation of new products and services would be hampered. For innovation to thrive in the production space it is important that the innovation environment conditions are healthy, governed by sound policy, with effective linkages across various conditions as well as the production space and consequently a market for consumption of the innovations.

3. Identification Strategy

We use the framework in Figure 1 above to understand policy factors that promote innovation. Consequently, we explore how individual innovation policies and their interactions influence innovation globally, in developed, and developing coutries. As such, our proxy for innovation that is labour productivity growth in non-traditional sector is modeled as a function of innovation policy and the effectiveness of innovation policy.

We assume the drivers of innovation to be; the intial level of labour productivity, the interaction of government effectiveness with educational expenditures, the interaction of government effectiveness with research and development and a facilitative business environment. We estimate the relationship with an Ordinary Least Squares regression with exogenous variation in explanatory variables of policy.

The dependent variable is defined as the natural log of the ratio of final to initial labour productivty, where final labour prodctivity is taken to be five years after the initial measure. The explanatory variables are lagged by 5 year. A three years average from the initial year is used to smoothen out one-off effects for the countries. The explanatory variables thus included in the estimation are the natural logartihm of initial labour productivity lagged five years, interaction of government effectiveness and government expenditures in tertiary education as a percentage of GDP lagged five years - hereon refered to as effective tertiary education expenditures, interaction of government effectiveness and gross expenditures on research and development percent GDP lagged five years - here on refered to as effective R&D expenditures and index of economic freedom lagged five years. Innovation is a medium to long term phenomenon and innovation policies typically take long time to bare fruit. Using lagged variable accomodates for long term nature of innovation and also provides a way to exclude reverse causality.

The literature provides evidence that intial level of labour productivity is a determinant of labour productvity growth. As such we account for initial level of labour productivity in the estimation equation (Barro, 1991). Also, initial level of education has an impact on how innovation policies influence the role of tertiary education expenditures on innovation itself (Keller, 2006). Natural resource and agricultural endowment also influences the growth path of a country (Lederman & Maloney, 2007). Finally a country's regional situation influences its growth trajectory as well (Moreno & Trehan, 1997). We introduce regional dummies, educational attainment in terms of years of education from primary to tertiary level, natural resource rents as a percent of GDP, and agricultural value added as a percent of GDP as additonal control variables. The estimation equation thus takes the form;

Equation 1: $$\Delta_{tN\text{-}t1}\ln(\text{labprod}) = \alpha_0 + \beta_o \bullet \text{labprod}_{t1} + \beta_1 \bullet \text{goveff}_{t1} \bullet \text{edu}_{t1} + \beta_2 \bullet \text{goveff}_{t1} \bullet \text{r\&d}_{t1} + \beta_3 \bullet \text{econfreedom}_{t1} + \text{natresrents}_{t1} + \text{agrirents}_{t1} + \text{eduattain}_{t1} + \text{regional dummies} + \hat{\epsilon}$$

Table 1 – Variable Definitions

Variable	Definition
Δ_{tN-t1} ln(labprod) **Log Productivity Growth**	Natural log of the ratio of final to initial labour productivity
labprod $_{t1}$ **Initial Productivity**	Natural log of initial labour productivity
goveff $_{t1}$ • edu $_{t1}$ **Effective Tertiary Education**	Interaction of government effectiveness and government expenditures on tertiary education as a percent of GDP - initial
goveff $_{t1}$ • r&d $_{t1}$ **Effective R&D**	Interaction of government effectiveness and gross expenditures on research and development as a percent of GDP - initial
econfreedom $_{t1}$ **Economic Freedom**	Index of economic freedom - initial
natresrents $_{t1}$ **Natural Resource Rents**	Natural resource rents as a percentage of GDP - initial
agrirents $_{t1}$ **Agricultural Value Added**	Agricultural value added as a percentage of GDP - initial
eduattain $_{t1}$ **Educational Attainment**	Number of years of schooling from primary to tertiary level - initial

Note: The subscript "t1" in Equation 1 and the reference "initial" in

Table 1 specifies the magnitude of the variable during the initial year(s) considered. The subscript "tN" in Equation 1 and the reference "final" in

Table 1 specifies the final year. As such the change in growth is considered between t1 and tN. In our work this period of growth is 5 years and the policy variables are lagged by 5 years from the final year for which a five-year growth rate is considered.

In addition, we evaluate the same equation for labour productivity growth including natural resource rents and agricultural value added. This helps us identify differences in the influence of innovation policies on pure innovation based growth versus mixed innovation and traditional sector growth and confirm the robustness of our results. We also estimate the model for developed and developing country groups separately to understand the differences in the influence of innovation policies and analyse the need of varying policies for both groups. The 15 year data from 1998 to 2013 data is regressed in three groups of five years. The results for each period are observed to understand period specific differences. These period specific difference are controlled for through a period dummy in the pooled dataset regression that is aimed at generating larger data set leading to significant and robust coefficients.

4. Data

Labour productivity is calculated in terms of real GDP per labour force. The labour productivity indicator is constructed by using the GDP from World Bank Development Indicators (World Bank, 2014) and number of employees' data from Penn Worlds Table Version 8.1 (Feenstra, et al., 2015). The use of Purchasing Power Parity (PPP) GDP ensures that the data is comparable across time and countries in level and growth rate. Literature suggests that innovation based growth is less likely to reflect in traditional industries such as those in natural resource and agricultural sectors (Becheikh, et al., 2006). As such the labour productivity growth measure excludes natural resource rents and agricultural value added. Total natural resource rents as a percentage of GDP is defined as the sum of; oil rents, natural gas rents, coal rents, mineral rents, and forest rents (World Bank, 2014). Agriculture in Agricultural value added corresponds to International Standard Industrial Classification (ISIC) divisions 1-5 and includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production.

Data for government expenditure on tertiary education as a percentage of GDP is acquired from the financial resources subset of the UNESCO Institute of Statistics education dataset (UIS.STAT, 2016). UIS.STAT receives data on education expenditure from country governments responding to UIS's annual survey on formal education. Tertiary education is considered as most important and direct contributor to innovation. When interpreting this indicator however, we should keep in mind that in some countries, the private sector and/or households may fund a higher proportion of total funding for education, thus making government expenditure appear lower than in other countries. Educational attainment is based on years of school life expectancy primary to tertiary.

Gross domestic expenditure on research and development or R&D (GERD) as a percentage of GDP is the total intramural expenditure on R&D performed in a national territory or region during a given year, expressed as a percentage of GDP of the national territory or region (UIS.STAT, 2016). The data is used as an indication of research and development policy. The ideal case would be to use GovERD that is government expenditure in research and development as a percentage of GDP. We use the GERD measure because it captures wider geographical and time space and is a good representative on what similar higher expenditures can achieve.

We use the Index of Economic Freedom as an indicator of government policy towards business. The Index of Economic Freedom is an annual index and ranking created by The Heritage Foundation and The Wall Street Journal in 1995 to measure the degree of economic freedom in the world's nations (Heritage Foundation & Wall Street Journal, 2016). The creators of the index took an approach similar to Adam Smith's in The Wealth of Nations, that "basic institutions that protect the liberty of individuals to pursue their own economic interests result in greater prosperity for the larger society". The index of economic freedom is based is on ten quantitative and qualitative factors; property rights, freedom from corruption, fiscal freedom, government spending, business freedom, labour freedom, monetary freedom, trade freedom, investment freedom, and financial freedom. Each of the ten economic freedoms within these categories is graded on a scale of 0 to 100. A country's overall score is derived by averaging these ten economic freedoms, with equal weight being given to each.

It would have been ideal to use Ease of Doing Business data from the World Bank Doing Business Indicators. The ten constitutive measures used in the composite ease of doing business indicator are, starting a business, dealing with construction permits, getting electricity, registering property, getting credit, protecting minority investors, paying taxes, trading across borders, enforcing contracts and resolving insolvency (World Bank, 2015). As such ease of doing business accounts for objective as well as subjective measures that are directly related to business policy in the country. However, due to limited time-period availability we resort to using the Index of Economic Freedom that relates to business environment in a relative bird-eye manner.

Government effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. (World Bank, 2015). It is notable that the indicator is a mix of quality and perception of infrastructure, bureaucratic, state, and policy stability. As such is used as a measure of expected effectiveness of innovation policies as related to the enabling conditions that effect linkages amongst various policy conditions and knowledge flow necessary for innovation *(See Figure 1 – Innovation Policy Framework Conditions)*.

Governance is difficult to account for using any kind of measure. As such we find it important to touch up on the topic of the selection of Government Effectiveness as an interaction term for the policy measures of expenditures in tertiary education and research and development in more detail. The representative sources for constructing this indicator include quality of bureaucracy, institutional effectiveness, excessive bureaucracy or red tape, infrastructure, quality of primary education, satisfaction with public transportation system, satisfaction with roads and highways, satisfaction with education system, basic health services, drinking water and sanitation, electricity grid, transport infrastructure, maintenance and waste disposal, infrastructure disruption, state failure, and policy instability. The composite is constricted from weighted average of the individual indicators obtain through an Unobserved Components Model (UCM). The UCM assigns greater weight to data sources that tend to be more strongly correlated with each other. This weighting improves the statistical precision of the aggregate indicators, and typically does not affect the ranking of countries much on the aggregate indicators. There are two rationales for using Government Effectiveness. First it is indicative of the governments' ability to implement their policies and as such the interactive term represents the efficiency of each dollar spent. Second, the interaction of Government Effectiveness with the expenditures can be looked at with much simpler view that is of representing the policies as related to the governance environment. Both explanations relate well to the definition of Government Effectiveness indicator and its use in the context of this paper and the framework represented graphically in Figure 1.

Table 2 - Summary Statistics

Variable	Countries	Years	Mean	Std Dev	Min	Max
Δ_{yN-y1} ln(labprod) Log Productivity Growth	150	1998-2013	0.55914	0.36419	-0.45232	1.54076
labprod $_{y1}$ Log Initial Productivity	157	1998-2013	9.61430	1.18327	6.88386	12.08405
goveff.edu Effective Tertiary Education	164	1998-2013	0.48310	0.42726	0.02356	2.19834
goveff.r&d Effective R&D	129	1998-2013	0.48488	0.71567	0.00331	3.42706
econfreedom Economic Freedom	177	1998-2013	57.74	12.19	8.9	89.06
natresrents Natural Resource Rents	187	1998-2013	6.29	10.56	0	86.17
agrirents Agricultural Value Added	164	1998-2013	16.83	14.51	0	61.80
eduattain Educational Attainment	182	1998-2013	11.79	3.21	3.1	20.23

Note: Description of abbreviations is provided in

Table 1

The indicator used to represent innovation based growth is the natural log of the ratio of final to initial labour productivity excluding natural resource rents and agricultural value added. It has a mean of 0.56 with a standard deviation of 0.36. The natural log of initial labour productivity in our dataset has a mean of 9.61 and a standard deviation of 1.18. As discussed previously, the variable effective government expenditures on tertiary education is constructed by interacting the index of government effectiveness with the government expenditures on tertiary education as a percent of GDP. The same approach is taken to construct the variable effective GERD as a percent of GDP. The prefix "effective" signifies an interaction with measure of government effectiveness.

Effective expenditure is obtained by the interaction of government effectiveness that runs from 0 to 1 by actual percent expenditures per GDP in the relevant policy areas. As such government effectiveness is translated as the percentage of effectiveness of each dollar spent or simply the interaction of the governance environment with the policy measures. The variable related to effective tertiary education expenditures and effective research and development expenditures have similar means of 0.48% however the standard deviation is 0.42 and 0.72 respectively.

The Index of Economic Freedom ranges from 8.9 at its minimum to 89.06 at its maximum level. It is noteworthy that the number of countries for which these data points are available varies from 129 for effective GERD percent GDP to 177 for index of economic freedom for the year between 1998 to 2013. However, in our regression between 95 to 106 countries are represented depending on the time period and extent of the data available. The correlation coefficient of effective tertiary education expenditures and effective research and development expenditures is 0.57. The same for Economic Freedom with effective tertiary education expenditures is 0.47 and with effective research and development expenditures is 0.51. The pairwise correlation between our explanatory variables of concern is considered moderate and is not expected have effect on the coefficients of the estimation. In order to make sure that this is the case we also regress excluding two of the explanatory variables and compare the results with the original estimation.

5. Results

Here we present the observed influences of the explanatory variables of concern, on the dependent variable i.e. labour productivity growth excluding natural resource and agricultural rents. Second, we present the result separately for developed and developing countries. Finally, we glance at how labour productivity growth for the Arabian Gulf countries compares with western countries.

The first result that is observed in Table 3 below is that of the "beta-convergence". That is, when the partial correlation between growth in income or productivity over time and its initial level is negative. It refers to a process in which poorer regions grow faster than richer ones and therefore catch-up on them. We observe that the initial labour productivity is negatively and statistically significantly correlated to labour productivity growth for pooled data for three periods. An increase of 1% in the country's initial labour productivity results in the ratio of final to initial labour productivity to be lower by 0.045%. Countries with relatively lower labour productivity are able to grow faster and hence converge to the frontier.

Table 3 – Labour Productivity Growth and Policy Variables

Dependent Variable	**Log Productivity Growth (Net of natural resource rents and agricultural value added)**					
	Period 1	Period 2	Period 3	Pooled	Pooled	Pooled
	1998-2003	2003-2008	2008-2013	Period 1 & 2	Period 2 & 3	Period 1, 2 & 3
Log Initial Productivity	-0.111***	-0.051	0.039	-0.075***	-0.022	-0.045**
	(0.038)	(0.037)	(0.028)	(0.025)	(0.027)	(0.021)
Effective Tertiary Education	0.024	0.035	0.041*	0.029	0.048*	0.041*
	(0.040)	(0.041)	(0.023)	(0.028)	(0.025)	(0.021)
Effective R&D	-0.005	-0.037	-0.01	-0.023	-0.022	-0.018
	(0.029)	(0.030)	(0.019)	(0.020)	(0.020)	(0.016)
Economic Freedom	0.003	0	-0.003	0.002	-0.002	-0.001
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
Arabian Gulf Dummy	-0.118	-0.268**	-0.148	-0.215**	-0.278***	-0.269***
	(0.142)	(0.125)	(0.114)	(0.087)	(0.097)	(0.078)
Period 1				-0.068***		0.103***
				(0.017)		(0.019)
Period 2					0.149***	0.147***
					(0.018)	(0.017)
R-squared	0.402	0.401	0.072	0.423	0.384	0.418
N	95	101	105	196	206	301
*** p<0.10, ** p<0.05, *** p<0.01**						

Note: Regional dummies, educational attainment, natural resource rents, and agricultural value added included as control variables

We observe that effective expenditures on tertiary education as a percent of GDP have a positive relationship in all periods with the explanatory variables. The pooled data for the three periods shows that there is a statistically significant positive relationship between effective tertiary education spending as a percent of GDP of the country and labour productivity growth. This is statistically significant at the 10% level for two sets of pooled data and for the third period. In this case, the magnitude of increase is considerable i.e. an increase of 1 percent in average effective tertiary education expenditure as a percentage of GDP would result in an increase of 4.2 % in labour productivity growth. To simplify, a country effectively investing 1 % of their GDP in tertiary education will improve their growth rate by 4.2% if they invest an equivalent of 2% of their GDP in tertiary education. Since this variable is represented by an interaction of government effectiveness and tertiary education expenditure as a percent of GDP it is useful to break down this result. A hypothetical country with 1% effective expenditure on tertiary education as a percent of GDP driven by 0.45 government effectiveness, investing 2.2 % of GDP as tertiary education expenditure and having an annual labour productivity growth rate of 3 percent can improve its productivity growth rate to 3.13 % (that is an increase by 4.2%) by increasing its effective expenditure to 2% that could be accomplished either by improving government effectiveness to 0.9 or tertiary education expenditure as a percent of GDP to 4.4 %.

We do not observe positive results for effective R&D expenditure percent of GDP for the complete set of countries. We observe no statistically significant results for Index of Economic freedom. The magnitudes are small and the pooled data for the three periods show inconsistent correlation for the business policy and labour productivity growth. The signs of the coefficients for effective tertiary education, effective R&D and Economic Freedom do not vary and the magnitudes do not vary by considerable extent when included individually in the estimation, that is, while excluding the remaining two explanatory policy variables. This confirms that the moderate pairwise correlation for our explanatory variables discussed in Section 4 has no influence on the results.

Table 4 shows results for developed and developing countries. It provides a perspective into differences in the relation of innovation policy to labour productivity between developing countries and developed countries. We can observe for developing countries in Table 4 effective research and development expenditures has a positive effect on labour productivity growth for developing countries [2] and the relationship is statistically significant at 10% level for the pooled data for three periods. An increase of 1 % in effective R&D expenditures as a percent of GDP in developing countries would result in an increase in the labour productivity growth rate to increase by 27.5 % for pooled data of periods 1, 2 and 3.

Table 4 – Labour Productivity Growth and Policy Variables – High Income OECD and Developing Countries Separately

Dependent Variable	**Log Productivity Growth Developed Countries**			**Log Productivity Growth Developing Countries**		
	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
	Period 1 & 2	Period 2 & 3	Period 1, 2 & 3	Period 1 & 2	Period 2 & 3	Period 1, 2 & 3
Log Initial Productivity	-0.001	0.057	0.032	-0.076**	-0.024	-0.043*
	(0.088)	(0.083)	(0.066)	(0.030)	(0.033)	(0.026)
Effective Tertiary Education	0.022	0.023	0.020	0.024	0.038	0.036
	(0.038)	(0.035)	(0.028)	(0.041)	(0.033)	(0.028)
Effective R&D	-0.006	-0.009	-0.009	0.164	0.165*	0.166*
	(0.020)	(0.019)	(0.015)	(0.103)	(0.097)	(0.079)
Economic Freedom	-0.002	0.002	0	0.002	-0.004	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
R-squared	0.172	0.632	0.491	0.349	0.326	0.321
N	44	45	67	127	135	196
*** p<0.10, ** p<0.05, *** p<0.01,**						

Note: Regional dummies, time dummies, educational attainment, natural resource rents, and agricultural value added included as control variables

This result is consistent with Nadiri and Kim (1996) who find the rate of return for domestic R&D spending to be between 23% and 26% varying amongst different countries. The breakdown of government effectiveness and R&D expenditures can be explained in similar terms as effective education expenditures as a percent of GDP. A hypothetical country with 1% effective expenditure on research and development as a percent of GDP driven by 0.45 government effectiveness, investing 2.2 % of GDP as research and development expenditure and having an annual growth rate of 3 percent

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[2] Note that when resource and agricultural dependency dummies are used instead of actual resource rents and agricultural value added the pooled data for three periods shows significant results at 10% for both effective tertiary education and R&D expenditures.

can improve its growth rate to 3.825 % (that is an increase by 27.5%) by increasing its effective expenditure to 2% that could be accomplished either through improving government effectiveness to 0.9 or research and development expenditure as a percent of GDP to 4.4 %. As in the case of the regression where all countries are included, we find that the signs of the coefficients for effective tertiary education, effective R&D and Economic Freedom do not vary and the magnitudes do not vary by considerable extent when included individually in the estimation. We find a positive effect of effective tertiary education on labour productivity growth for both developed and developing countries. However, the coefficients are not significant as it was observed in the case of the pooled data for all countries. Robustness tests show that the inclusion of natural resource rents and agricultural value-added in the regression equation (instead of resource dependency dummy) does not change the results. The exclusion of the educational attainment represented by average years of schooling also does not affect the results.

We have excluded the possibility of reverse causality. In our work, we have accounted for initial economic state of the country, initial level of educational attainment in the country region specific differences, and time specific differences. Also, the labour productivity growth variable is lagged by a period of five years in order to exclude the possibility of reverse causality. As such we can assume plausible causality in the case where we observe statistically significant relationships. As such it is plausible that an interaction of higher government effectiveness and higher investment in tertiary education as a percent of GDP leads to higher labour productivity growth excluding natural resource and agricultural rents that acts as a proxy of innovation.

Arabian Gulf countries - A special case?

We also present results for Arabian Gulf country dummies in contrast to the reference region Western Europe and Nordic countries in Table 5 below and compare them to those already seen in Table 3 above. We observe much lower growth in labour productivity in non-traditional sector in comparison with the reference group. With rising oil prices from 2003 onwards most of the growth in Arabian Gulf economies was based on resource rents. We observe in Table 5 below that the same regression without excluding natural resource rents and agricultural value added, results in diminished statistical significance for the Arabian Gulf countries' dummy variable for the pooled sets. This result indicates that the growth in non-natural resource sector has been slower in comparison with the reference group. It is noteworthy that the coefficient of the Arabian Gulf Dummy is significant for Period 2 in both cases where labour productivity growth excludes and includes natural resources rents. Periods 1 and 3 also corresponds with low oil prices.

Table 5 – Total Labour Productivity Growth and Policy Variables

Dependent Variable	**Log Productivity Growth (Inclusive of natural resource rents and agricultural value added)**					
	Period 1	Period 2	Period 3	Pooled	Pooled	Pooled
	1998-2003	2003-2008	2008-2013	Period 1 & 2	Period 2 & 3	Period 1, 2 & 3
Log Initial Productivity	-0.084***	-0.053**	0.009	-0.074***	-0.041	-0.065***
	(0.026)	(0.026)	(0.022)	(0.018)	(0.027)	(0.020)
Effective Tertiary Education	0.013	0.036	0.011	0.022	0.013	0.007
	(0.028)	(0.029)	(0.018)	(0.020)	(0.025)	(0.020)
Effective R&D	-0.014	-0.050**	-0.006	-0.030**	-0.027	-0.019
	(0.020)	(0.021)	(0.015)	(0.015)	(0.020)	(0.016)
Economic Freedom	0.001	-0.002	-0.001	-0.001	-0.003	-0.002*
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)
Arabian Gulf Dummy	-0.098	-0.164*	-0.08	-0.112*	-0.081	-0.065
	(0.098)	(0.088)	(0.092)	(0.064)	(0.097)	(0.074)
R-squared	0.402	0.401	0.072	0.423	0.384	0.418
N	95	101	105	196	206	301
*** p<0.10, ** p<0.05, *** p<0.01**						

Note: Regional dummies, time dummies, educational attainment, natural resource rents, and agricultural value added included as control variables

As such we corroborate the effect of oil price on non-traditional sector labour productivity growth. In Figure 2 the predicted labour productivity growth excluding natural resource rents and agricultural value added for two Arabian Gulf countries (Oman and Saudi Arabia) and two reference group countries (Netherlands and Norway) is plotted against the annual growth rate of crude oil price. The predicted labour productivity growth function is computed for each country by using their respective data points and estimation results of pooled data for periods 1, 2 and 3 as shown in Table 3. In Figure 2 it is observed that lower non-traditional sector labour productivity growth in the Arabian Gulf countries Oman and Saudi Arabia is associated with higher oil prices and vice versa but not for the two countries from the reference group Norway and Netherlands. This provides confirmation that the representation of the non-traditional sector in labour productivity growth of the Arabian Gulf countries is partly driven by oil prices.

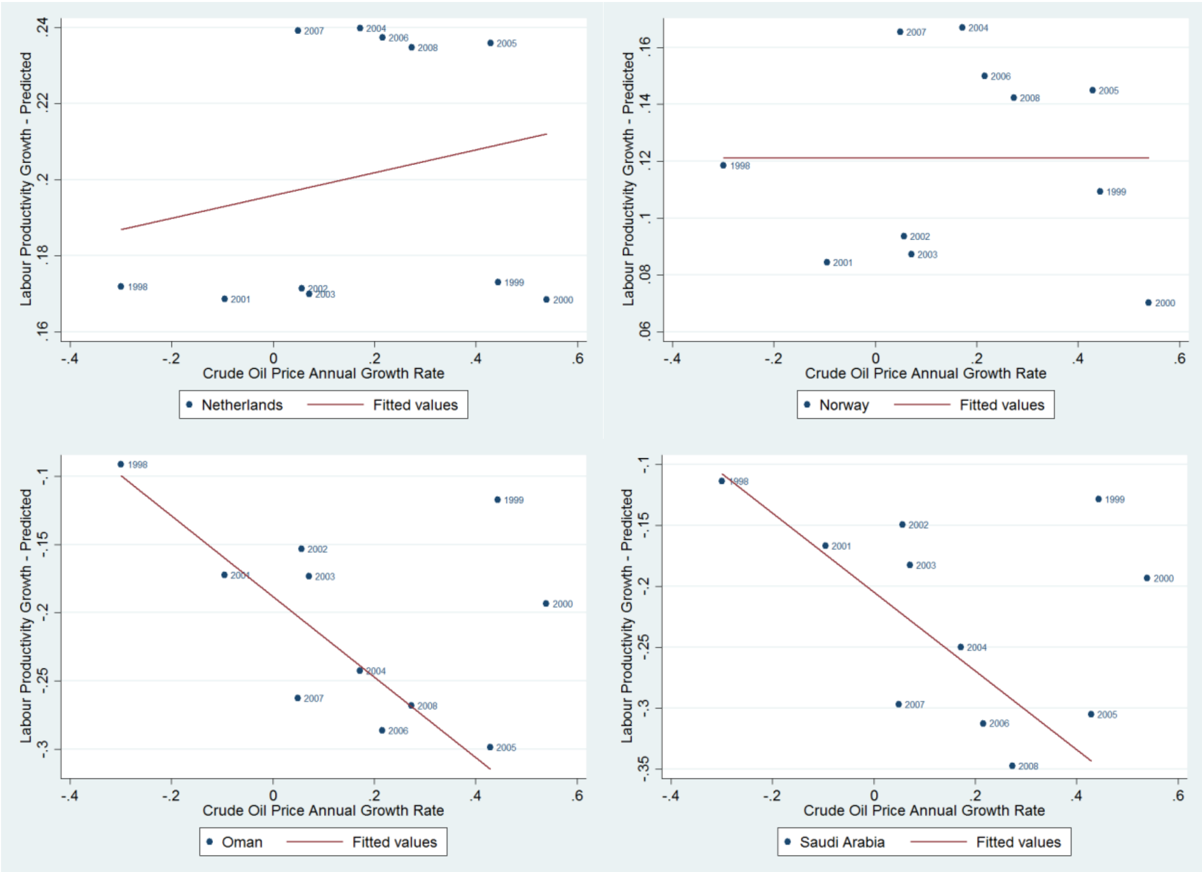

Figure 2 – Predicted labour productivity growth as a function of annual growth rate of crude oil prices

6. Conclusions and Discussion

This paper presents the analyses of the relationship between innovation policy and innovation. It establishes the correlation and plausible causality between innovation policies and labour productivity growth in a cross-sectional evaluation among countries. A selection of innovation policies was chosen based on literature review and state-of-the-art “broad” innovation policy approach. Innovation policy in this work is represented by indicators of investment and policy index representing three major innovation policy areas of education, research and development, and business. The policy implementation capability and potential of the governments are also considered critical and analysed.

We observe in our results the convergence in labour productivity between richer and poorer countries – beta-convergence, in line with earlier findings (Barro, 1991; Barro, 2012) . Also, Verspagen’s (1991) work confirms the catching-up of relatively backwards countries through technological spill-overs. Further we observe that there is significant and positive relationship between the interaction of government effectiveness and government expenditure in tertiary education, and labour productivity excluding natural resource and agricultural rents for pooled data for period 1, 2 and 3. This answers one of the question raised in Keller (2006) where the returns to tertiary education are not found to be consistently positive. Keller (2006) hypothesizes that tertiary education expenditures might be inefficiency allocated. We consider the multiplicative term of government efficiency and tertiary education investment and found this term positively and significantly related to labour productivity growth in non-traditional sectors for most pooled data. We could also challenge the notion that primary and secondary investment has priority over tertiary education investment on the basis of economic return, by including the initial educational attainment in the form of years of education primary to tertiary in the explanatory variables. However, the initial level of educational attainment turns out to be non-significant in all specifications. This is important for policy makers as it demonstrates significant societal returns to tertiary education.

When separating developing countries and developed countries we observe that the significance of effective tertiary education disappears. At the same time for developing countries the coefficients for effective R&D expenditures show consistently positive and statistically significant for most of the pooled data. This contrasts with findings elsewhere which often highlight the importance of research and development expenditures for developed countries speculating the opposite for developing countries. For example, Griffith et al (2004) point out that developing countries are not able to achieve the maximum potential in R&D. They see this as a consequence of inappropriate social policies. Our results highlight indeed that the influence of the interaction of government effectiveness with research and development expenditures on labour productivity growth (excluding natural resource and agricultural rent) is positive. Through these results, the importance of looking at innovation policies as a complete set within an innovation eco-system rather than only looking at them individually is highlighted further. These results are unique and first of their kind in confirming the interaction of sound governance and innovation policy measures such as expenditures in tertiary education and research and development, even though the significance of the coefficients is not too strong (10%).

We do not find any relationship between labour productivity growth and the index of economic freedom. In other words, we cannot demonstrate that a good business environment is conducive to the transformation of knowledge and research into marketed goods and services. The results may be a consequence of the type of indicator we have selected to represent the quality of business environment. The variable used presents only a bird-eye view of the business environment. But perhaps also our specification fails to catch a potentially shorter response time to business policies. It would be ideal in future research to work with different time lags for business conditions and to work with indicators that objectively represent the business policy and environment in the countries.

Arabian Gulf countries experience lower labour productivity growth in non-traditional sector as the oil prices increase. For these countries, a crucial policy implication is to devote resources towards tertiary education and R&D, while improving government effectiveness, if they want to grow independent of oil and gas resources.

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8. Appendix A

Table A1 – Data Sources

Variable	Source
GDP PPP	World Bank – World Development Indicators (World Bank, 2014)
Number of employees	Penn Worlds Tables – Version 8.1 (Feenstra, et al., 2015)
Natural resource rents	World Bank – World Development Indicators (World Bank, 2014)
Agricultural value added	World Bank – World Development Indicators (World Bank, 2014)
Government effectiveness	World Bank – World Governance Indicators (World Bank, 2015)
Government expenditures on tertiary education as a percent of GDP	UNESCO Institute for Statistics (UIS.STAT, 2016)
Gross expenditures on research and development as a percent of GDP	UNESCO Institute for Statistics (UIS.STAT, 2016)
Index of economic freedom	Heritage Foundation and Wall Street Journal (Heritage Foundation & Wall Street Journal, 2016)
Years of school life expectancy primary to tertiary	UNESCO Institute for Statistics (UIS.STAT, 2016)

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