The Gains from More Competitive Regulation Settings in Canada

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Abstract

This article explores potential gains for Canada from making its regulatory framework as competition friendly as that in the United States. We estimate standard cross-country GDP growth regressions incorporating the OECD's indicators of product market regulations (PMRs) that measure the extent to which regulations, laws and other rules inhibit product market competition. Based on the key point estimate (or the lower bound of its 95 per cent confidence interval), GDP per capita in Canada could be about 2.0 per cent (0.7 per cent) higher in the medium term (i.e. 5 years) and about 5.3 per cent (1.8 per cent) higher after 20 years as a result of making Canada's 2013 regulatory settings related to foreign direct investment (FDI) as competitive as in the United States. However, government actions taken since 2013 have improved the competitiveness of these regulations. As a result, further changes needed to reach the US benchmark are not as great as they were in 2013 and would not generate as substantial gains.

In addition to setting the right framework for economic growth, key objectives for government are attaining desirable non-financial outcomes for society such as safe workplaces and a clean environment. However, the multitude of such objectives and the many means of achieving them make design of regulation exceedingly difficult. For example, a particular objective (e.g. a given level of product safety) can be achieved through several approaches, with some designs being more economically costly than others.

In that context, there are potential gains from rationalizing and improving the regulatory framework, the regulations, laws and other rules influencing economic activity. However, the magnitude of these potential gains is unclear. The objective of this article is to examine the potential benefits of making regulations, laws and other rules more competition friendly after taking interactions within the economy into account. We concentrate in particular on the scale at the aggregate level of comprehensive reform rather than targeting

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individual changes. To this end, we introduce the classic Solow model with a wedge between the resources spent and those that are effectively used to build productive capital. In other words, we assume the competition inhibiting nature of some regulations dissipate productive resources. In practical terms, and in the tradition of Mankiw *et al.* (1992) and Islam (1995), we estimate a dynamic equation for GDP per capita with an added term reflecting the extent to which regulations are anti-competitive.

Critical to this analysis is an indicator of the anti-competitiveness of regulation. To this end, we utilize the product market regulation (PMR) measures developed by the OECD. These measures are compiled from a survey of laws and regulations in each country.[2] They capture a variety of aspects such as state involvement (e.g. does the government restrict purchase of shares by foreigners?) and business operation restrictions (e.g. are there restrictions on store opening hours?) that increase the economic costs by limiting competition and the optimal allocation of resources. As such, changes in these indicators do not necessarily imply weaker standards on pollution, and health and safety, but rather affect the extent to which existing regulations reduce competition. Indeed, improvement in these indicators is consistent with the objective to put in place smarter, more effective approaches to regulation that enhance economic competitiveness, while maintaining high standards of public health and safety, and protecting the environment.

It is important to note that the OECD PMR indicators capture regulations, laws and other rules set by different levels of government and by those organizations to which regulatory power has been delegated such as self-regulating professional associations. Consequently, we acknowledge that our use of the term "regulation" does not strictly adhere to the definitions used by different governments or international organizations and that, in some contexts, the broad term "policy" could be used interchangeably with "regulation." Finally, the set of regulations on which the measures are based is narrow compared to the universe of all regulatory policies affecting economic activity. As a consequence, cross-country differences in the PMR indicators only arise from cross-country differences over relatively few policies. Nevertheless, these measures are adequate for our purposes so long as the regulations on which the indicators are based reflect their broader universe. We believe that the OECD indicators are the best available measures to evaluate the degree to which countries' regulatory frameworks inhibit competition.

Though our methodology does not treat the possible endogenous relationship between growth and regulatory settings, our findings suggest anti-competitive regulation lowers GDP per capita, particularly if it raises barriers to trade and investment. This means that even though Canada performs well in several areas, such as having low barriers to entrepreneurship, Canada has room to improve and increase welfare. Reducing the anti-competitive elements of Canada's regulatory framework as they stood in 2013, in particular those related to foreign direct investment (FDI), to US levels that serve as a feasible high-competition benchmark, would be expected to increase GDP per capita in Canada by up to 2.0

2 These measures are based on surveys that are answered by government organizations. Surveys are initially disseminated to finance ministries where upon the OECD encourages these departments to farm out questions to the most relevant bodies. As a result, questions may be provided by sub-national governments.

per cent within five years (i.e. the medium term). As the capital stock adjusts fully in the long run, this alignment could increase GDP per capita by about 5.3 per cent. Based on the lower bound of our main point estimate's 95$^{\text{th}}$ confidence interval, the medium and long-run impacts are estimated to be about 0.7 and 1.8 per cent respectively.

It is worth noting that convergence of the PMR indices between the two countries is not a convergence in regulations, laws and other rules but rather a convergence in the anti-competitive burden they impose. For barriers to FDI restrictions, this would entail in part relaxing to the same extent as in the United States, Canadian equity limits or obligatory screening and approval procedures for foreign investors as they attempt to acquire domestic businesses. Also worth noting is that since 2013, some elements of the regulatory environment have become more competitive in Canada; the OECD's FDI restrictiveness index suggests this is the case for Canadian FDI regulations. As a result, the reforms needed for current regulations to reach the US benchmark should not be as great and cannot be expected to generate as large benefits as indicated here.

We concentrate in this analysis on potential gains of making the regulatory framework more competitive and therefore remain at a high level of generality. We hope that the scope of such gains leads to further analysis of actual gains in the light of more specific reform proposals. Clearly, those actual gains may be smaller than those suggested here when practical constraints on policy are introduced. We emphasize, however, that the potential for gains are large: many of the industries examined are networked industries that could benefit from greater scale and increased competition between providers of intermediate goods and services to downstream firms that could lead to large knock-on effects.

In what follows, the first section specifies the regression equation we estimate and describes the data we use. Section 2 presents the results and tests their robustness. Section 3 concludes and suggests some necessary caveats to the analysis.

Data and Estimation Strategy

Estimation Equation

The regression equation we estimate is derived from a modified version of the Solow model that accounts for how PMRs might affect growth (see the Technical Appendix for the derivation of the regression equation).[3] Specifically, the equation we estimate is given by,

$$\begin{aligned}\ln \frac{Y_{c,t}}{L_{c,t}} =& \beta_1 PMR_{c,t} + \beta_2 \ln s^k_{c,t} + \beta_3 \ln s^h_{c,t} + \\ & \beta_4 \ln(n_{c,t} + g + \delta) + \beta_5 \ln \frac{Y_{c,t-\tau}}{L_{c,t-\tau}} + \\ & \eta_c + m_t + \epsilon_{c,t}\end{aligned} \tag{1}$$

For the most part, equation (1) is a standard growth regression. In this equation, $Y_{c,t}$ and $L_{c,t}$ are respectively the levels of output (i.e. GDP) and population in country c in year t. As in the literature, this equation proposes output per capita is explained most notably by a country's investment rates in physical $s^k_{c,t}$ and human $s^h_{c,t}$ capital, the combined effect of its rates of population growth $n_{c,t}$, technological

3 We acknowledge that this regression might be derived from different models or that it could be thought of as a simple reduced form equation without explicit theoretical underpinnings.

progress g and capital depreciation δ,[4] and output per capita in the previous period (in this case τ periods in the past). Moreover, as in Islam (1995), equation (1) allows constant but unobserved country-specific factors η_c and time varying but global shocks m_t to influence growth. Finally, $\epsilon_{c,t}$ represents idiosyncratic random and unobserved shocks that influence growth. These shocks are assumed to be independently and identically distributed as well as being unrelated to other factors that theory suggests also drive growth.

As elsewhere in the literature (e.g. Wolfl *et al.*, 2010), equation (1) includes the anti-competitive nature of product market regulations $PMR_{c,t}$ as a factor influencing growth. The intuition for why $PMR_{c,t}$ affects growth is that with less competition caused by poorly designed regulations, less investment is able to build productive capital. As a result of this investment wedge, the marginal impact of more anti-competitive regulations is to decrease output per capita by β_1 per cent in the medium term (here τ or 5 years) and $\frac{\beta_1}{1-\beta_5}$ per cent in the long term, once the effective stocks of capital fully adjust.

Data

Analysis and estimation of equation (1) requires economic and education data as well as measures quantifying the general stance of country regulations towards competition.

Product Market Regulation

The PMR measures used to estimate equation (1) are obtained from the OECD (Koske *et al.*, 2015). These measures are based on information about regulations, laws and other rules or policies set by different levels of government and self-regulating bodies. The end result is a set of quantitative measures that allow one to trace indicator values to underlying policies. Furthermore, indicators are based on OECD member country surveys with few based on external data sets. Moreover, the indicators are based on a country's actual policies and not on opinions reflecting subjective assessments of market participants. They measure potentially anti-competitive elements of regulations and rules where competition is possible, and generally do not reflect market outcomes. Finally, national administrations of OECD member countries peer review these indicators.

The PMR indicators are available for OECD countries and selected non-OECD countries for up to four years (i.e. 1998, 2003, 2008, and 2013). As well, these PMR measures are available at various levels of aggregation. For example, at a high level of aggregation, the OECD PMR measures capture regulations limiting competition due to 1) state control, 2) barriers to entrepreneurship and 3) barriers to trade and investment. Moreover, these measures are aggregated from more specific types of regulations. At their most basic level, these metrics measure the scope by which public enterprise, license and permit systems, and barriers to FDI can limit competition. Finally, the PMR measures range in value from zero to six where higher values represent a higher anti-competitive burden.

4 We follow Mankiw *et al.* (1992) and Islam (1995) in assuming the rate of technological progress and the depreciation of physical capital add up to 5 per cent (i.e. $g + \delta = 0.05$) but we undertake sensitivity analysis around this value. These results are available upon request.

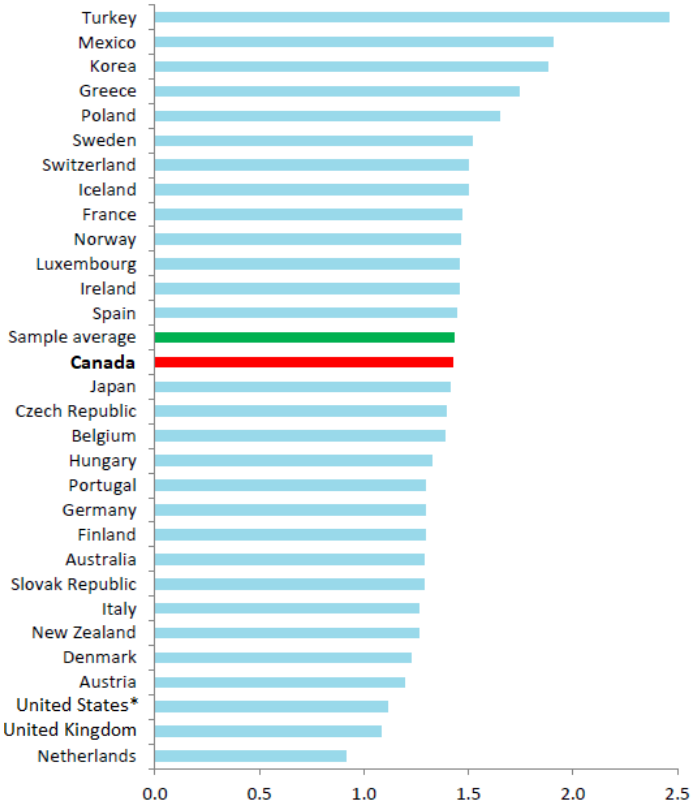
Table 1: OECD Product Market Regulation Indicators by Country and Year, 1998, 2003, 2008, 2013

	Overall average high-level PMR					State Control					Entrepreneurship					Trade and investment				
	1998	2003	2008	2013	Country Average	1998	2003	2008	2013	Country Average	1998	2003	2008	2013	Country Average	1998	2003	2008	2013	Country Average
Australia	1.72	1.34	1.46	1.29	1.45	2.28	1.59	2.21	1.99	2.01	1.94	1.76	1.65	1.69	1.76	0.95	0.67	0.53	0.19	0.58
Austria	2.12	1.61	1.37	1.19	1.57	3.09	2.33	1.95	1.67	2.26	2.50	1.79	1.46	1.31	1.76	0.78	0.71	0.71	0.60	0.70
Belgium	2.30	1.64	1.52	1.39	1.71	3.16	2.35	2.15	2.19	2.46	3.02	2.26	2.12	1.78	2.29	0.71	0.30	0.30	0.18	0.37
Canada	1.91	1.64	1.53	1.42	1.62	2.15	2.08	1.96	1.92	2.03	1.82	1.44	1.36	1.34	1.49	1.75	1.40	1.27	1.01	1.36
Czech Republic	2.64	1.88	1.50	1.39	1.85	3.28	2.58	2.11	1.95	2.48	2.77	2.19	1.90	1.82	2.17	1.87	0.85	0.48	0.42	0.90
Denmark	1.66	1.48	1.35	1.22	1.43	2.32	1.83	2.03	1.97	2.04	2.45	2.12	1.55	1.26	1.85	0.23	0.48	0.48	0.45	0.41
Finland	1.94	1.49	1.34	1.29	1.52	2.75	2.26	2.18	2.13	2.33	2.36	1.77	1.58	1.55	1.82	0.70	0.45	0.27	0.20	0.40
France	2.38	1.77	1.52	1.47	1.78	3.41	2.83	2.41	2.37	2.76	3.18	2.09	1.74	1.68	2.17	0.54	0.40	0.40	0.35	0.42
Germany	2.23	1.80	1.41	1.29	1.68	2.57	2.15	1.99	1.86	2.14	2.95	2.41	1.90	1.66	2.23	1.16	0.84	0.34	0.36	0.68
Greece	2.75	2.51	2.21	1.74	2.30	4.24	3.81	3.33	2.82	3.55	3.06	2.89	2.53	1.91	2.60	0.96	0.82	0.79	0.49	0.77
Hungary	2.66	2.11	1.54	1.33	1.91	3.40	2.47	2.03	2.05	2.49	2.81	2.30	2.20	1.69	2.25	1.78	1.57	0.38	0.24	0.99
Iceland	2.03	1.62	1.48	1.50	1.66	2.60	1.93	1.84	1.97	2.08	2.82	2.18	2.17	2.07	2.31	0.68	0.74	0.43	0.45	0.58
Ireland	1.86	1.58	1.35	1.45	1.56	3.00	2.50	1.84	2.12	2.37	2.35	2.02	1.99	1.98	2.08	0.23	0.23	0.23	0.26	0.23
Italy	2.36	1.80	1.49	1.26	1.73	3.82	3.15	2.58	2.14	2.92	2.61	1.67	1.30	1.22	1.70	0.65	0.59	0.58	0.42	0.56
Japan	2.11	1.37	1.43	1.41	1.58	1.87	1.66	1.90	1.85	1.82	3.22	1.69	1.65	1.67	2.06	1.24	0.75	0.74	0.71	0.86
Korea	2.56	1.95	1.94	1.88	2.08	2.60	2.10	2.44	2.47	2.40	2.63	2.40	2.16	1.87	2.26	2.44	1.37	1.23	1.30	1.58
Luxembourg	.	1.60	1.44	1.46	1.50	.	2.69	2.34	2.45	2.49	.	1.87	1.75	1.71	1.78	0.29	0.22	0.22	0.21	0.24
Mexico	2.76	2.50	2.05	1.91	2.31	2.58	2.28	2.12	2.02	2.25	3.06	2.59	2.45	2.19	2.57	2.63	2.63	1.58	1.52	2.09
Netherlands	1.82	1.49	0.96	0.92	1.30	2.97	2.28	1.44	1.43	2.03	2.22	1.92	1.31	1.19	1.66	0.27	0.27	0.14	0.12	0.20
New Zealand	1.45	1.29	1.23	1.26	1.31	1.18	1.55	1.93	2.06	1.68	2.06	1.64	1.09	1.18	1.49	1.10	0.66	0.66	0.53	0.74
Norway	1.87	1.56	1.54	1.46	1.61	2.81	2.18	2.20	2.13	2.33	2.19	1.88	1.82	1.69	1.90	0.60	0.60	0.60	0.57	0.59
Poland	3.19	2.42	2.04	1.65	2.33	2.97	3.57	3.32	3.06	3.23	3.45	3.11	2.49	1.64	2.67	3.15	0.59	0.33	0.24	1.08
Portugal	2.59	2.12	1.69	1.29	1.92	4.04	3.42	2.89	2.18	3.13	2.82	2.05	1.83	1.35	2.01	0.91	0.91	0.35	0.35	0.63
Slovak Republic	.	2.18	1.62	1.29	1.69	.	3.07	2.36	2.17	2.53	.	2.15	1.74	1.15	1.68	.	1.30	0.77	0.55	0.87
Spain	2.39	1.79	1.59	1.44	1.81	3.69	2.49	2.16	1.86	2.55	3.06	2.47	2.20	2.10	2.46	0.42	0.42	0.42	0.37	0.41
Sweden	1.89	1.50	1.61	1.52	1.63	2.21	1.91	2.39	2.22	2.18	2.85	1.99	1.81	1.71	2.09	0.62	0.62	0.62	0.62	0.62
Switzerland	2.49	1.99	1.55	1.50	1.88	3.05	2.75	2.66	2.68	2.78	2.94	2.51	1.62	1.56	2.16	1.46	0.71	0.37	0.26	0.70
Turkey	3.28	2.82	2.65	2.46	2.80	4.42	4.15	3.66	3.44	3.92	3.57	3.03	2.90	2.78	3.07	1.86	1.29	1.40	1.16	1.43
United Kingdom	1.32	1.10	1.21	1.08	1.18	1.68	1.15	1.63	1.57	1.51	1.96	1.82	1.74	1.49	1.75	0.32	0.32	0.25	0.20	0.27
United States	1.50	1.30	1.11	.	1.31	1.62	1.43	1.50	.	1.52	1.97	1.64	1.23	.	1.61	0.91	0.85	0.60	.	0.78
Cross-country average	2.21	1.78	1.56	1.44	1.73	2.85	2.42	2.25	2.16	2.41	2.66	2.12	1.84	1.66	2.06	1.08	0.79	0.58	0.49	0.74

Source: OECD Product Market Regulation database (See Koske *et al.*, 2015).

Note: Averages reflect the unweighed arithmetic averages. The cross-country average reflects the average value of specific PMR variable in a given year across countries. The country average reflects the average value a specific PMR variable takes for a specific country over the sample periods.

Chart 1: Overall Average Product Market Regulation Standings, 2013



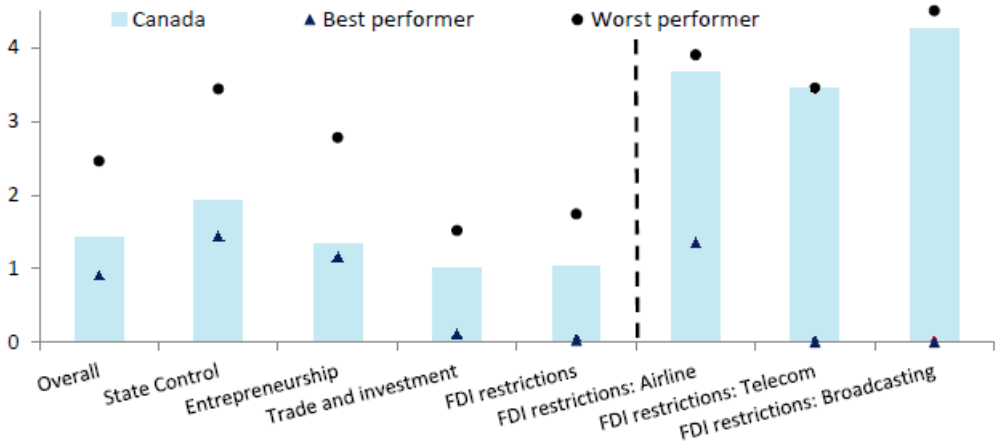
Source: OECD PRM Database.
Note: The PMR index ranges from 0 to 6. Lower values connote regulations that are more competition friendly. In this respect, a value 0 identifies situations where existing regulations do not limit competition unnecessarily. The "Sample average" reflects the unweighted average PMR value of sample countries.
* The US value is for 2008.

Table 1 shows three high-level PMR measures and their overall average in each year for the 30 OECD countries that compose our sample.[5] In 2013, Canada's overall competitive level according to the PMR measures was near the sample median and average (Chart 1). This overall standing however hides a regulatory environment that was relatively competitive in many areas.[6] As shown by Chart 2, Canadian regulations related to state control inhibited competition relatively little as Canada's PMR value was relatively close to that of Netherlands, the country with the most competition friendly state control regulations in the sample. Similarly, even though entrepreneurial barriers in professional services and the retail sector were comparatively high, Canada's average anti-competitive nature of regulations related to entrepreneurship was nearly as low as in the best performing sample country, the Slovak Republic. Canadian regulations that were fairly anti-competitive were those related to trade and investment. Here, Canada's PMR was above the sample median. This standing was mainly driven by Canada's barriers to FDI that were more anti-competitive than in most other sample country. Of particular note were Canada's high FDI restrictions that affected the airline, telecommunications, and broadcasting sectors that influenced the general barriers to FDI measure.

5 The overall average PMR is the unweighted average PMR value for the State Control, Entrepreneurship, and Trade and Investment indicators.

6 Indeed, while Canada was the 16th and 26th in 2013 out of 30 OECD countries most competitive according to the overall and the trade and investment indicators, it was the 7th most competitive with respect to the entrepreneurship and state control indicators.

Chart 2: Canada's Relative PMR Performance by Component, 2013



Source: OECD PRM Database and OECD FDI restrictions Database.
Note: The PMR index ranges from 0 to 6. Lower values connote regulations that are more competition friendly. FDI restrictions is a subcomponent of the Barriers to trade and investment PMR measure. The FDI restrictions measure is, in part, a function of FDI restrictions in the Airline, Telecom and Broadcasting sectors.

Over time, the PMR measures declined in all countries, suggesting the regulatory frameworks are becoming more competitive. Increases in competitiveness however diminished over time. Chart 3 shows this as the overall PMR measure saw its greatest decline between 1998 and 2003 with only minor further declines. This was the case for Canada as well as the median, best and worst performing sample country. This potentially reflects that countries initially liberalized where it was easiest, leaving for the future further reform that would be harder to make (Koske *et al.*, 2015) or would have a smaller effect.

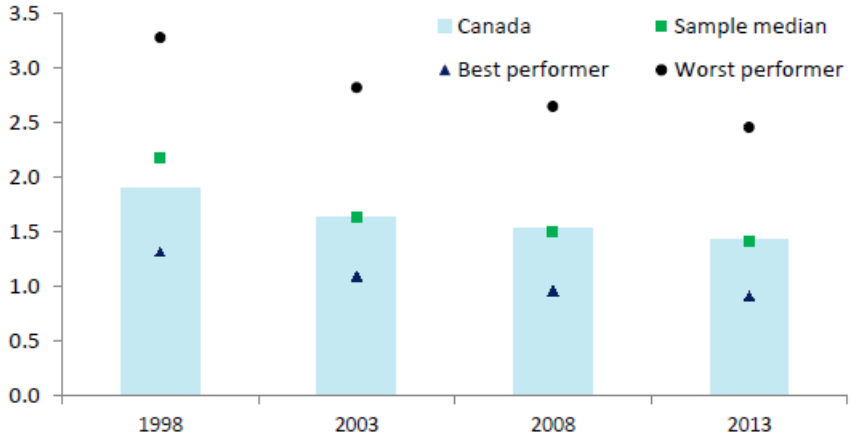
Table 1 and Chart 3 show Canada's PMRs became more competitive over time. However, these changes were not as substantial as in most other countries; while Canada's overall average PMR decreased by 0.48 points (1.91 to 1.42) from 1998 to 2013, the average and median decrease for sample countries was 0.79 and 0.85 respectively. This could have occurred if by 1998 Canada had already largely liberalized regulations that were easiest to change. Indeed, while Canada's overall average PMR in 1998 was not as low as in the UK (1.32, the best performer in 1998) or the US (1.50), it was far lower than in Turkey (3.28, the worst performer in 1998) or the sample median (2.17). In fact, Canada's measure ranked it as the tenth most competitive regulatory framework in our sample in 1998. As a result of ranking relatively low initially on the PMR spectrum, Canada could have expected to see lower gains as liberalization could have been relatively more difficult than in most other countries.

Economic Data

The economic data were obtained from the OECD productivity and national accounts databases[7] and the Penn World Tables (Version 7.0). These data sources provide international comparable data for various countries. They differ though in the periods they covered. OECD data extend forward enough in time to be able to be used with the most recent period available of PMR measures but some series do not go far enough back. Conversely, the Penn World

7 These databases are available at stats.oecd.org.

Chart 3: Overall Average PMR Measure Over Time, 1998-2013



Source: OECD PRM Database.
Note: The PMR index ranges from 0 to 6. Lower values connote regulations that are more competition friendly.

Tables series extend far enough back in time but not enough forward to be compatible with the latest PMR data. As a result, we splice together these two data sources; we use OECD series and extend them back using Penn World Data. We use these data sources to determine the physical capital investment rate (i.e. $s^k_{c,t}$, annual physical capital investment as a share of GDP), population growth, and GDP per capita.

In creating the panel data we follow Islam (1995) and calculate $s^k_{c,t}$ and $n_{c,t}$ over multi-year periods. Specifically, $s^k_{c,t}$ and $n_{c,t}$ for 1998, 2003, 2008 and 2013 are averages calculated using data over the periods 1995-1999, 2000-2004, 2005-2009 and 2010-2014, respectively. These periods are chosen in part so that the year in which the PMR measures are available is near the mid-point of each period. Given the available PMR measures fall within each of these four periods, we presume these measures represent the average PMR level for each period in each respective country. Finally, the GDP per capita data used in our analysis is the annual value of the last year of each five-year period in the sample. For example, in the 2010-2014 period, the dependant variable reflects GDP per capita in 2014.[8]

Merging the PMR and economic data leaves a panel of 30 OECD countries that have at least three or four consecutive years of data that we label as 1998, 2003, 2008 and 2013.[9] This gives an unbalanced panel with 116 observations. Given the constraints imposed by the OECD PMR measures, one may suspect estimates to be sensitive to small changes in the data or sample. This issue will only be alleviated with time as the time series length and country coverage expand.

Although consisting of only OECD members, our sample of countries is diverse. The sample ranges from advanced (e.g. G7 members) to emerging (e.g. Mexico, Poland, and Turkey) economies. This diversity is borne out, for example, by the range in the level of GDP per capita across sample countries. Expressed in internationally comparable dollars, GDP per capita in 2013

8 Generally, a stronger relationship exists when we use GDP per capita in the year that coincides with the PMR measures. These results are not shown here but are available upon request.

9 We only use the 30 OECD countries because the sparse availability of PMR measures over time for the other countries does not allow them to be included in our analysis.

Table 2: Summary Statistics

		Full sample: All sample countries		Canada	
		mean	sd	mean	sd
A.	Product market regulations				
	Overall average high-level PMR	1.74	0.48	1.62	0.21
	State control	2.42	0.67	2.03	0.11
	Entrepreneurship	2.07	0.56	1.49	0.22
	Trade and investment	0.73	0.56	1.36	0.31
B.	Economic data (USD, constant prices, 2010 PPPs)				
	GDP per capita	35,238	13,235	38,992	2,737
	Previous period GDP per capita	32,565	12,911	36,276	3,768
	Productivity (GDP per hour)	43.72	15.31	44.70	3.07
	Previous period productivity	40.86	15.29	42.11	3.27
	Physical capital investment rate (per cent)	22.7	3.8	21.8	2.6
	Population growth rate (per cent)	0.6	0.5	1.0	0.1
C.	Education data (per cent)				
	Secondary/tertiary education enrolment rate	13.0	2.4	12.4	0.7

Sources: OECD PMR, OECD ESTAT database. Note: Averages and standard deviations are based on variable values for all 30 sample countries over the entire sample period. Investment reflects total economy investment and includes investment in dwellings. Investment is expressed in real terms, constant price PPP adjusted USD. Finally, enrollments rates are based on the total number of all students in all age groups enrolled in secondar/tertiary education.

ranged from a minimum of $18,135 in Mexico to a maximum of $102,101 in Luxemburg.

In our empirical work, we use GDP per capita as the dependant variable, consistent with the growth literature. Although GDP relative to the numbers of workers or hours worked would be more consistent with our theoretical model, GDP per capita is used for two main reasons. First, data on employment or hours are not as widely available on a comparable basis. For example, OECD labour data are often missing countries or years or contain series with various breaks. Second, using GDP per worker may lead to misleading conclusions on the impact of regulatory reforms on living standards. For example, if reforms were to increase the aggregate employment rate by encouraging those previously not searching for work — and who may be less-skilled — to enter the labour force, it could lead to a fall in GDP per worker although per capita GDP would increase.[10] Nevertheless, later in the article, we test the robustness of our baseline results by using GDP per hour rather than GDP per capita as the dependant variable.

Education Data

Following Mankiw *et al.* (1992) we proxy the national investment rate in human capital by the school enrolment rate (i.e. $s^h_{c,t}$). However, unlike Mankiw *et al.* we use the rate of enrolment in tertiary and secondary education rather than just secondary education. This difference extends from the difference in samples used. Mankiw *et al.* use a

10 This is a possible reason why previous work focusing only on OECD countries (e.g. Nonneman and Vanhoudt, 1996; Arnold *et al.*, 2007; Boulhol *et al.*, 2008) used GDP per capita as the dependant variable.

broader sample of developed and developing countries that would likely allow sufficient variation in the secondary school enrolment rate. In contrast, not as much variation is expected in the enrolment rate in secondary education of countries in our sample because most of our sample countries are developed. Consequently, we use the combined enrolment in tertiary and secondary education because this rate may provide more variation for the sample of countries we use. Panel C of Table 2 shows the summary statistics for this variable.

The data on tertiary enrolment rates are obtained from the OECD Education and Training database on student enrolment. These data are available for all sample countries on an annual basis for most years since 1990.[11]

Results and Robustness

The OECD provides national measures of PMRs at various levels of aggregation. For the purposes of this note we focus on an overall average PMR measure before assessing more specifically what regulations most affect growth.

Results

Overall Average High-level PMR

As a baseline, Column 1 and 2 of Table 3 present OLS estimates of equation (1) when country-fixed effects are respectively excluded and included in estimation. In comparing these columns, it can be inferred that accounting for constant country-specific factors is important. Without country-fixed effects anti-competitive regulations are seen to have a positive although statistically insignificant effect on GDP per capita. However, this result may be due to estimation bias stemming from omitted variables, a type of bias Islam (1995) suggests may exist in cross-sectional growth regressions that fail to include country fixed effects. Indeed, if country fixed effects are included in estimation, the conclusion about the potential impact of PMRs changes substantially. With fixed effects, Column 2 suggests PMRs are negatively related to growth in a statistically significant way. Specifically, the marginal impact of the PMR measure is estimated to be -0.062. Although country fixed effects resolve omitted variable bias in estimation, including these dummy variables introduces endogeneity that can also bias results. This endogeneity arises because the lagged dependant variable on the right-hand-side of equation (1) becomes correlated with the error term when country fixed effects are used. Moreover, this endogeneity is exacerbated when the time dimension of each panel is short, as in our case. Going forward, to resolve this endogeneity and the original omitted variable bias, we focus exclusively on a general method of moments (GMM) estimation procedure outlined by Arellano and Bond (1991). Briefly, this procedure first addresses the omitted variable problem by first differencing the estimation equation and then using instrumental variables (IVs) to deal with the correlation between the lagged dependent variable on the right-hand-side and the error term. Finally, it is important to note that the Arellano and Bond method does not address any issues related to the potential endogeneity inherent when using a policy variable like

11 However, the data are missing in some years for some countries. Fortunately, every country in the sample has these data in at least one year in each of the sample periods. Consequently, any gaps in the data may not be a serious problem as we are ultimately interested in the average enrolment rate in each country over each period. As long as we have at least one year of enrolment in each period we should have a sufficient approximation of the actual average enrolment rate in the period.

Table 3: Effect of Overall High-Level Average PMR on GDP per Capita

	OLS	**OLS**	**AB GMM**
	(1)	(2)	(3)
Overall average high-level PMR	0.0053	-0.0621*	-0.0750*
	(0.023)	(0.029)	(0.034)
log(physical capital investment rate)	0.081**	0.120*	0.182**
	(0.031)	(0.052)	(0.059)
log(secondary/tertiary education enrolment rate)	0.076*	0.099**	0.086*
	(0.030)	(0.036)	(0.034)
log(pop growth rate + 0.05)	0.028	-0.133	-0.241
	(0.064)	(0.135)	(0.144)
log(previous period GDP per capita)	0.934**	0.682**	0.802**
	-0.023	-0.1	(0.129)
Year fixed-effects	YES	YES	YES
Country fixed effects	NO	YES	NO
R2/Pseudo-R2	0.98	0.99	0.97
Observations	116	116	86
Number of countries	30	30	30
Arellano/Bond second order auto-correlation coefficient (P-value below)	NA	NA	1.26
	NA	NA	(0.21)

Robust standard errors in parentheses. ** p<0.01, * p<0.05. The pseudo-R2 is given by the correlation between the actual and predicted outcome variable.

the PMR measures in cross-country growth regressions.

Column 3 of Table 3 presents results based on the preferred Arellano and Bond estimation method. Using this method, the impact of the overall average PMR measure remains negative and statistically significant. However, the impact increases in magnitude; the marginal impact of the overall average PMR measure is estimated to equal -0.075.[12] These estimates thus suggest that lowering the Canadian PMR measure as it stood in 2013 (1.42) to the US level for 2008, the latest year for which data are available (1.11), a feasible level in a comparable but generally more competitive economy, is expected to increase GDP per capita by about 2.4 per cent over the medium term (i.e. five years).[13] After 20 years, the change would yield an increase in GDP per capita of about 7 per cent. Due to estimation variability, however, the impact of these changes could be considerably lower. Based on the lower bound of the medium-term estimate's 95 per cent confidence interval, the medium-term and 20-year impacts on GDP per capita could be as low as 0.3 and 0.8 per cent respectively given the same estimate of β_5, the lagged GDP per capita's coefficient.

12 It is important to note that with four years of observations it is possible to test an underlying assumption of the Arellano and Bond method, namely that the second order autocorrelation of the first differenced errors is insignificant. Based on our sample this auto-correlation is statistically significant at neither the 1 per cent nor 5 per cent level.

13 We calculate the 2.4 per cent increase in GDP per capita by multiplying the coefficient on overall PMR variable in column 3 (-0.075) with the difference in this measure between US in 2008 and Canada in 2013 (about -0.31) and 100.

Table 4: Effect of Underlying Regulations on GDP per Capita in OECD Countries

	Arellano/Bond GMM		
	(1)	(2)	(3)
State control PMR	0.0037		
	(0.015)		
Public Ownership		0.0068	0.0075
		(0.013)	(0.014)
Involvement in business operation		-0.0016	-0.0009
		(0.014)	(0.014)
Entrepreneurship PRM	-0.043*		
	(0.020)		
Complexity of regulatory procedures		-0.011	-0.012
		(0.007)	(0.007)
Administrative Burden on start-ups		-0.032	-0.034
		(0.018)	(0.018)
Regulatory protection of incumbents		-0.010	-0.012
		(0.020)	(0.020)
Trade and investment PMR	-0.039		
	(0.026)		
Explicit barriers to trade and investment		-0.0365*	
		(0.016)	
Barriers to FDI			-0.0392**
			(0.013)
Tariff barriers			-0.013
			(0.008)
Other barriers to trade and investment		-0.016	-0.016
		(0.014)	(0.014)
Other controls	YES	YES	YES
Year fixed-effects	YES	YES	YES
Country fixed-effects	NO	NO	NO
Pseudo R2	0.97	0.97	0.97
Observations	86	86	86
Number of countries	30	30	30
Arellano/Bond second order auto-correlation coefficient (P-value below)	1.074 (0.28)	1.119 (0.26)	1.094 (0.27)

Robust standard errors in parentheses. ** p<0.01, * p<0.05. The pseudo-R2 is given by the correlation between the actual and predicted outcome variable.

PMRs by Component

The arbitrary nature in which OECD PMR indicators are aggregated to the overall average PMR could allow the true relationships between regulations and growth to be distorted. As well, some types of regulations may not negatively affect GDP per capita. For this reason, we re-estimate equation (1) using all three high-level PMR measures. We also re-estimate using the more disaggregated measures underlying the high-level measures to further avoid arbitrary weightings and to obtain a better indication of more specific regulations that obstruct growth.

Table 4 suggests reducing barriers to trade and investment may be what yields the GDP gains seen on Table 3. In disaggregating the overall average PMR into its three higher-level PMR measures, Column 1 in Table 4 suggests that regulations creating barriers to entrepreneurship are a drag on GDP per capita. Indeed, the estimated marginal impact of these barriers is -0.043 and is the only measure to be statistically significant. It is reasonable to suspect that less entrepreneurship can reduce growth. However, further disaggregation of the high-level PMRs may be still warranted to determine more narrowly the regulations that inhibit growth.

In disaggregating the high-level PMRs into their narrower components, Column 2 suggests barriers to entrepreneurship may not be the main driver of lower growth. Results in this column suggest instead barriers related to trade and investment have a significant impact. While no underlying PMR related to entrepreneurship has a statistically significant impact, regulations creating barriers to FDI and trade do; the marginal effect of this PMR is estimated to equal -0.037.

Finally, in distinguishing between regulations creating barriers to trade and investment (i.e. FDI), Column 3 shows that the impediment is created by barriers to FDI. These barriers would arise when, for

example, any equity limits or obligatory screening and approval procedures exist for foreign investors as they attempt to acquire domestic businesses.[14] Canada's barriers to FDI are comparatively high in the telecom and retail sectors. The marginal effect of regulations that explicitly impede FDI is estimated to be -0.039 with a statistical significance of one per cent. Given this estimate, if Canada were to reform and make its policies as competitive as in the US, GDP per capita would increase by 2.0 per cent in the medium term and 5.3 per cent after 20 years. Based on the lower bound of the 95 percent confidence interval for the medium term impact, the effect would be as slow as 0.7 per cent in the medium term and 1.8 per cent after 20 years.

Extensions and Robustness

GDP per hour as the dependant variable

According to our theoretical model, GDP per hour or productivity should be the dependant variable in our empirical work rather than GDP per capita (Durlauf *et al.*, 2005). The likely reason why most of the literature does not use GDP per worker or hours worked as the dependant variable is because these hours or employment data are not broadly available. Indeed, the productivity measures are not available for all current 35 OECD countries over the entire sample period in most OECD databases. Furthermore, Korea experienced dramatic variation in its number of total hours worked during the Asian Crisis of the late 1990s and so this country's productivity measures likely incorporate substantial noise. If Korea is a general example, GDP per capita may also be the preferred dependant variable because it could be less susceptible than GDP per hour to noise introduced by the business cycle or economic crises.

Given the different considerations of which dependant variable is most appropriate for our work, in this section we test the robustness of our baseline results by using GDP per hours worked as the dependant variable.[15] The list of countries is the same as for the baseline results with the exception of Korea. Because outliers are known to affect significantly the empirical results in the growth literature (Durlauf *et al.*, 2005), we exclude Korea as an outlier.[16]

Panel A of Table 5 shows the GMM estimates of the regression model that differ based on the level of disaggregation of the PMR measures. In general, some evidence exists that anti-competitive regulations related to trade and investment are what matter most for growth. However, this evidence is not definitive. Column 1 shows that the only high-level PMR measure to have a statistically significant relationship with productivity is the one related to barriers to trade and investment.

14 Other regulations featuring in the PMR measure for barriers to FDI are restrictions on the employment of foreigners as key personnel and operational restrictions (e.g. restrictions on branching and on capital repatriation or on land ownership) (Kalinova *et al.*, 2010). This is the same as for the OECD's FDI restrictiveness index. As a consequence, countries may raise FDI barriers even if foreigners are able to purchase fully domestic companies because they may face restrictions in other dimensions.

15 The GDP per hour series is obtained from the OECD Productivity database.

16 Korea is an outlier because of its amazing productivity growth observed over our sample period; GDP per hour worked in Korea increased by 100 per cent between 1995 and 2010 according to OECD data! This was about three times greater than the average or median productivity growth rate observed in our sample. This feat stands out in addition to Korea's significant variation in the number of hours worked during the Asian Crisis of the late 1990s.

Table 5: Robustness - Productivity and Sample

	A: Productivity as dep. var.			B: Sample excludes poorest 3 countries		
	(1)	(2)	(3)	(4)	(5)	(6)
State control	-0.0174			0.0124		
	(0.011)			(0.013)		
Public Ownership		-0.0202*	-0.0216**		0.0118	0.0106
		(0.008)	(0.008)		(0.0120)	(0.011)
Involvement in business operation		0.0041	0.0046		0.0118	0.0122
		(0.012)	(0.012)		(0.012)	(0.012)
Entrepreneurship	-0.0156			-0.0428*		
	(0.017)			(0.020)		
Complexity of regulatory procedures		-0.0092	-0.0098		-0.0056	-0.0060
		(0.006)	(0.005)		(0.006)	(0.006)
Administrative burdens on start -ups		0.0215	0.0191		-0.0472**	-0.0504**
		(0.0166)	(0.017)		(0.018)	(0.019)
Regulatory protection of incumbent		-0.0096	-0.0086		-0.0178**	-0.0154**
		(0.019)	(0.019)		(0.017)	(0.016)
Trade and investment	-0.0328*			-0.0831**		
	(0.015)			(0.025)		
Explicit barriers to trade and investment		-0.0010			-0.0253	
		(0.016)			(0.031)	
Barriers to FDI			0.0074			-0.0268*
			(0.028)			(0.012)
Tariff barriers			-0.0078			-0.0024
			(0.010)			(0.022)
Other barriers to trade and investment		-0.0135	-0.0128		-0.0463**	-0.0453**
		(0.010)	(0.010)		(0.009)	(0.010)
Other controls	YES	YES	YES	YES	YES	YES
Year fixed-effects	YES	YES	YES	YES	YES	Yes
Country fixed effects	NO	NO	NO	NO	NO	NO
Pseudo R2	0.86	0.83	0.83	0.96	0.96	0.96
Observations	82	82	82	77	77	77
Number of countries	29	29	29	27	27	27
Arellano/Bond second order auto-correlation coefficient (P-value below)	-1.44 (0.15)	-1.69 (0.09)	-1.55 (0.12)	0.41 (0.68)	0.27 (0.79)	0.17 (0.87)

Sample Robust standard errors in parentheses. ** p<0.01, * p<0.05.

The pseudo-R2 is given by the correlation between the actual and predicted outcome variable.

Note: In Panel B, the poorest 3 countries are: Mexico, Poland and Turkey.

Determination of the poorest countries is based on PPP adjusted GDP per capita in 1998.

Its marginal effect is -0.033 and is of similar magnitude to the point estimates of underlying PMR measures that are statistically significant in Table 4 (i.e. -0.037 and -0.039). However, unlike Table 4, Column 2 and 3 in Table 5 show that no underlying measure of the high-level barriers to trade and investment PMR are statistically significant. Instead, these columns show that regulations directing the scope of public ownership are what matter for productivity growth. This is the only occasion when these regulations are found to have any sort of statistically significant relationship with productivity or GDP per capita. Consequently, we conclude that evidence exists showing that more anti-competitive regulations related to trade and investment limit GDP per capita and GDP per hour. However, this evidence should be taken with caution.

Sample Countries

Sample countries are currently OECD members and can be considered as developed or as fairly advanced emerging economies. Nevertheless, to consider what might be the impact of reducing the anti-competitive nature of regulations in more developed countries such as Canada, some sample countries might not be sufficiently advanced to be comparable. To this end, to assess the robustness of main results in Tables 3 and 4, we drop the poorest three countries (as judged by PPP adjusted GDP per capita in 1998) from the sample.

After dropping, Turkey, Poland and Mexico from the sample (i.e. the poorest sample countries in 1998), results in Panel B of Table 5 continue to indicate that regulations erecting barriers to trade and investment inhibit growth. That is, the main finding gleaned from Table 4 is robust. In all three specifications, a component of barriers to trade and investment is negatively and statistically significantly related to GDP per capita. For example, the marginal effect of the high-level trade and investment PMR measure in Column 4 is estimated to be -0.083. With further disaggregation, as Column 5 shows, this effect emerges from regulations labeled as

"other barriers to trade and investment." These regulations pertain in part to the differential treatment of foreign suppliers and barriers to trade facilitation that would arise when, for example, foreign suppliers are treated less favourably regarding taxes or eligibility to subsidies than domestic suppliers. The combined marginal effect of these regulations is estimated to be -0.046. With further disaggregation, Column 6 shows that regulations creating explicit barriers to FDI are an additional source of lower GDP per capita; though smaller in magnitude than in Column 3 of Table 4, the marginal effect is negative (i.e. -0.027) and statistically significant.

An added finding from Columns 5 to 6 is that the source of the lower growth might be found more broadly than in just regulations related to barriers to trade and investment. Regulations limiting entrepreneurship might be more germane in inhibiting growth. Specifically, as Columns 5 and 6 suggest, administrative burdens on start-ups are statistically significantly related to growth.

Conclusion

Our results suggest changing regulations to make them more competition friendly, while maintaining high standards of health and safety and environment protection, could have a positive impact on GDP per capita in Canada. Specifically, GMM estimates suggest that making Canadian regulations as competitive-friendly as in the United States with respect to FDI, as measured by the OECD PMR measures, could increase GDP per capita by 2.0 per cent over the first five years and 5.3 per cent after 20 years as the capital stock increases. Such a change would in part entail relaxing, to the same extent as in the United States, Canadian equity limits or obligatory screening and approval procedures for foreign investors as they attempt to acquire domestic businesses. Since 2013 some FDI related regulations have been reformed and so further changes to reach the US benchmark are not as large and so may not generate as significant gains.

Our estimates are of similar magnitude to estimates elsewhere in the literature. Using Italian firm-level data, Lanau and Topalova (2016) suggest decreasing the PMR measure in nine regulated industries by a comparable amount as we do here would increase average total factor productivity in downstream industry by about 7.5 per cent.[17] Gal and Hijzen (2016) find that "the short-term effects of product market reforms are positive and strengthen over time." At the firm level, major reform in 10 regulated industries seems to lead output to increase by about 3 per cent and employment between 1.5 and 2 per cent after two years, suggesting labour productivity also increases commensurately over this period.[18]

Finally, focusing on network industries across 26 industrialized countries, Bouis *et al.* (2016) find that major product market regulations that have facilitated entry have

17 This estimate is based on the estimated impact of decreasing the PMR measure by one standard deviation. The change needed to make the Canadian barrier to FDI PMR level to the United States in 2008 is equivalent to 1.25 standard deviations of this variable in 2013.

18 One way Gal amd Hijzen (2016) define "major reform" is as any annual change in their PMR regulation indicator that is greater than the 95th percentile. For our work, the change necessary to bring Canada level to the US PMR value for barriers to FDI is about the same as the 95th percentile of changes in this measure among OECD countries from 2008 to 2013.

allowed increases in output and productivity respectively of about 10 to 14 per cent after only about 5 years after reforms.

As suggested by Gal and Hijzen (2016) the long-term benefits of product market reform are well accepted though adjustment costs make it unclear what the net gains are in the shorter term. However, the work here and that of Gal and Hijzen (2016) and Egert and Gal (2016) suggest that net benefits of reform can be fairly immediate. As well, appropriately designed policies (e.g. active labour market policies) could be used to complement regulatory reform by mitigating some of the short-run costs of adjustment. As for the impact of PMR reform on income inequality, the impact is unclear. Reform seems to increase employment, which can diminish household income inequality, but it also widens wage disparities (OECD, 2011). Moreover, given that reform can impact people in the same part of the income distribution differently depending on where the reform bites in the economy, determination of the impact of PMR reform on income dispersion may need to be done on a case by case basis (OECD, 2014).

Given our analysis, some caveats are necessary. Some are relatively minor. For example, our findings may overestimate the net welfare gains arising from alignment with the United States. This may arise as the improved economic outcomes we measure come at the cost of exacerbating any negative externalities of competition that we cannot account for (e.g. changes in income inequality). Another minor caveat is that our findings may be sensitive to data revisions or other changes in the sample. This arises because data limitations give us only a small sample with which to work.

Other caveats are more fundamental. The theoretical model we use does not endogenize the technological growth rate. This limitation may be important since regulations may affect this rate. Indeed, Conway and Nicoletti (2007) suggest that barriers to competition in Canada discouraged firms from exploiting advances in information and communication technology between 1980 and 2005. Another fundamental caveat is that the relationship between GDP and PMRs may be endogenous and so cause our estimates to be biased.[19] Given the different ways GDP and PMRs could be endogenously related it is difficult to assess the direction of any bias. Instrumental variable techniques could be used to obtain unbiased estimates but this approach often proves difficult to carry out satisfactorily and without controversy.

Finally, we note regulatory reform undertaken alone by any one level of government or self-regulating body may yield gains that are smaller than what we estimate. This is because the regulations, laws and other rules comprising the general regulatory environment and that are reflected by the PMR measures fall under various jurisdictions. Consequently, a concerted effort between all stakeholders would be needed to achieve the needed reforms and commensurate gains.

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19 This is not unlike the problem described by Acemoglu and Robinson (2001) when discussing the literature on institutions and development.

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Technical Appendix

Following the treatment of the Solow model in some parts the growth literature, we assume each country c operates a constant returns to scale aggregate production, $F_c(\cdot)$, benefiting from total factor productivity (TFP), $A_c(t)$. Moreover, we assume production utilizes only three inputs: physical capital ($K_c(t)$), human capital ($H_c(t)$), and labour ($L_c(t)$). For simplicity, the aggregate production function is assumed to be Cobb-Douglas and characterized by,

$$F(K_c(t), H_c(t), A_c(t)L_c(t)) = K_c(t)^{\alpha} H_c(t)^{\theta} [A_c(t)L_c(t)]^{1-\alpha-\theta} \quad (2)$$

In this functional form, α and θ are positive fractions, and $\alpha + \theta \in (0, 1)$.

As in the Solow model, we assume TFP increases exogenously over time with technological progress. In our model, the rate of technological progress is assumed to be the same across all countries and constant over time. As a result, the path of TFP is given by,

$$A_c(t) = A_c(0)e^{gt} \quad (3)$$

In this equation, $A_c(0)$ is country c's initial TFP level.

We introduce the effect of PMRs into the model as a wedge between what is invested in physical and human capital and what builds either type of capital. As in the Solow model, a country invests a share of aggregate output to build new capital to replace depreciated capital and potentially augment its stock. In our model, the shares of output invested in physical and human capital

are represented respectively by $s^k_{c,t}$ and $s^h_{c,t}$. However, unlike the canonical Solow model, we assume that only a portion of investments builds productive capital. As a result, for capital type (either physical (k) or human (h)) the effective investment rate is given by $s^x_{c,t}G^x$ (PMR). Here, the value of G^x (PMR)$\in$ $[0,1]$ and is a decreasing function of PMR (i.e. $G^{x\prime}$(PMR) <0). In this respect, PMR is taken to be a measure reflecting the anti-competitive nature of the regulatory framework that wastes resources and is assumed to take on non-negative values (i.e. PMR$\in$ $[0,\infty)$).

Defining, physical and human capital per effective worker as $k_c(t) = \frac{K_C(t)}{L_C(t)}$ and $h_c(t) = \frac{H_c(t)}{L_c(t)}$, the Solow model has two fundamental equations, one for each type of capital per effective worker. Given these two fundamental equations we can derive the steady state levels for each type of capital. These are

$$\begin{aligned} k^*_{c,t} =&[(s^k_{c,t}G^k(PMR))^{1-\theta}]^{\frac{1}{1-\alpha-\theta}} \\ &[(s^h_{c,t}G^h(PMR))^{\theta}]^{\frac{1}{1-\alpha-\theta}} \\ &[n_{c,t}+g+\delta]^{-\frac{1}{1-\alpha-\theta}} \end{aligned} \tag{4}$$

and

$$\begin{aligned} h^*_{c,t} =&[(s^k_{c,t}G^k(PMR))^{\alpha}]^{\frac{1}{1-\alpha-\theta}} \\ &[(s^h_{c,t}G^h(PMR))^{1-\alpha}]^{\frac{1}{1-\alpha-\theta}} \\ &[n_{c,t}+g+\delta]^{-\frac{1}{1-\alpha-\theta}} \end{aligned} \tag{5}$$

. By linearizing the system of fundamental equations around $k^*_{c,t}$ and $h^*_{c,t}$ we can solve the system to express GDP per worker as a function of exogenous parameters, a country's PMR, and the lagged value of GDP per worker. If we assume $G_{c,x}(PRM) = W_{c,x}e^{\gamma_x PMR}$ for $x \in (k,h)$, the dynamic equation is expressed specifically as,

$$\begin{aligned} \ln\frac{Y_c(t)}{L_c(t)} =&(\alpha\gamma_k+\theta\gamma_h)(\frac{1-e^{-\lambda\tau}}{1-\alpha-\theta})PMR+ \\ &\alpha(\frac{1-e^{-\lambda\tau}}{1-\alpha-\theta}\ln\big(s^k_{c,t}\big)+ \\ &\theta(\frac{1-e^{-\lambda\tau}}{1-\alpha-\theta}\ln\big(s^h_{c,t}\big)+ \\ &e^{-\lambda\tau}\ln\frac{Y_c(t-\tau)}{L_c(t-\tau)}- \\ &(\alpha+\theta)(\frac{1-e^{-\lambda\tau}}{1-\alpha-\theta})\ln(n_{c,t}+g+\delta)+ \\ &[(1-e^{-\lambda\tau})A_c(0)+ \\ &(\frac{1-e^{-\lambda\tau}}{1-\alpha-\theta})\ln\big(W^\alpha_k W^\theta_h\big)]+ \\ &(t-e^{-\lambda\tau(t-\tau)})g \end{aligned} \tag{6}$$

Once a random shock term is added to equation (6), the equation can then be simplified to be expressed as equation (1),

$$\begin{aligned} \ln\frac{Y_{c,t}}{L_{c,t}} =&\beta_1 PMR_{c,t}+\beta_2\ln s^k_{c,k}+\beta_3\ln s^h_{c,k}+ \\ &\beta_4\ln(n_{c,t}+g+\delta)+\beta_5\ln\frac{Y_{c,t-\tau}}{L_{c,t-\tau}}+ \\ &\eta_c+m_t+\epsilon_{c,t} \end{aligned} \tag{1}$$