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A FRIENDLY FIRE ON ECONOMIC RECOVERY: A Methodology to Estimate the Costs of Data Regulations

by Erik van der Marel, Senior Economist at ECIPE, Matthias Bauer, Senior Economist at ECIPE and Hosuk Lee-Makiyama, Director at ECIPE*

ABSTRACT

This background paper describes the methodology used for the ECIPE Occasional Paper called 'The Costs of Data Localisation: A Friendly Fire on Economic Recovery' in which the costs of data services regulation are assessed. This paper provides further explanation on how the costs of data regulation affect industries and firms in four different ways. First, we calculate the costs of data regulation for domestic firms by establishing a link between regulation in data services and the level of total factor productivity (TFP) at industry level across countries in downstream sectors. As such, this is the first attempt at analysing this linkage econometrically by setting up a data protection regulation index using a typology of existing indices of services regulation. The regression analysis reveals that data regulation indeed tends to affect TFP in industries which depend more heavily on data processing services. Second, we provide relative cost estimates as a result of data regulation that affects foreign exporting firms for each of the countries and industries considered in this study. This is because foreign firms face upfront investment and operational costs when data regulations are applied by the host government. Third, this paper assesses the costs for investment made in the host country as a consequence of data regulation. Finally, the costs of research and development (R&D) activities which are affected by regulation in data services are also taken into account as constraints on the free flow of data could, in addition, decrease innovation activities by firms. Together these four ways of measuring costs of data regulation are used for a general equilibrium analysis using the Global Trade Analysis Project (GTAP) to estimate the GDP, trade effects and investment costs as presented in the ECIPE study.

* Corresponding author: erik.vandermarel@ecipe.org. The authors would like to thank Bert Verschelde, Research Associate at ECIPE who was also part of this project, for his excellent research input during this project. We also gratefully appreciate discussions with Sang-Seung Yi and Kyungsin Park on this research.

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www.ecipe.org

info@ecipe.org Rue Belliard 4-6, 1040 Brussels, Belgium Phone +32 (0)2 289 1350

1. INTRODUCTION

Data protection is a new type of regulation which can bring significant costs for domestic and foreign firms according to economic theory (Christensen *et al.* 2013). However, how these regulations affect the performance of firms remains unclear and, to date, no empirical assessment has been undertaken regarding the way in which data protection may affect the output of the firm. This paper is therefore first in presenting various empirical approaches in an attempt to analyse the four channels through which data services regulation impacts the performance of firms. In particular, it assesses the extent to which domestic firms, foreign exporting firms and firms that invest and innovate are affected.

Regulation of data flows presents a relatively new feature in the broader spectrum of services regulation. It concerns rules on how personal data is utilised by firms in the interaction between consumers and producers. Consumers can be exposed to the release of their personal data on numerous occasions such as while using their credit cards when economic transactions are taking place, or during instances that can range from using social media to accessing healthcare services. As in most other services sectors, regulation of the market is often required to prevent consumers from negative spill-over effects caused by the inefficient organisation of the sector due to market failures. Examples include asymmetrical information in the financial sector as well as inefficient network systems in telecom services, or the existence of natural monopolies in the gas and electricity network. In data services, one market failure concern is failing to protect the personal data of consumers that is held by producers, which can also be seen as a type of asymmetrical information.

As in all services sectors, the challenge for policy makers is to find the right balance between developing necessary regulations that are linked to a particular social objective and implementing these regulations at minimum cost in terms of economic welfare so that they do not create an unnecessary burden for firms. Yet, new rules on data protection for consumers could also have detrimental effects as shown by Bauer *et al.* (2013). This is because data services regulations would have a side-effect of restricting transactions between domestic and foreign operators, which in turn limits the efficient sourcing of data processing activities. These regulatory restrictions can therefore inhibit downstream performance in other sectors of the economy in which data processing is an important input for production such as the Machinery industry or Business services. This paper is the first to test such a link between data services regulations on the one hand and the adverse cost impact on downstream firms, plus the upfront fixed and operational costs for foreign exporting firms, in addition to the costs of less efficient investment and innovation for firms.

This paper contributes to the existing literature in the following ways. First, in order to calculate the negative impact of domestic firm performance, we develop a regulatory index that serves as a proxy indicator for data processing services regulation. It does so through an assessment of the different types of regulatory barriers currently existing in various OECD and emerging economies. We then use this index to assess whether regulation in the data processing services sectors has an impact on downstream producers. To undertake this step, we apply an identification strategy that supposes that more intense users of data processing services will be hurt to a greater extent than firms where data processing services only account for a small share of total input use. This empirical strategy closely follows Arnold *et al*. (2011) and Arnold *et al*. (2012). We then estimate the effect of regulation in data processing services on the economic performance of downstream producers in terms of TFP for a cross-section of countries over time. As such, we develop a channel through which data regulation affects domestic firms. Finally, we augment our data services protection index with the recently proposed data protection measures of eight countries and estimate the precise TFP costs for these countries by sector.

Second, we calculate the upfront fixed costs and operating costs that foreign exporting firms using data services as inputs need to incur when exporting their goods and services to the host (importing) country. We do so by using newly published data on the relative data centre investment costs in the countries considering introducing new data services regulation. Finally, this paper also takes stock of the impact on investment and innovation as a consequence of data services regulation. Together these four channels, through which data regulations are measured, form the basis of analysis on how we think data regulation affects the entire economy.

The remainder of this paper is organised as follows. The next section gives a short discussion about the related literature on data processing and data services regulation. This review is rather short since the issue of data services regulation is relatively new. Section 3 starts with the empirical strategy of our analysis and describes how we have developed the cost estimate for domestic firms using data services. Sections 4 and 5 present our regression results of this exercise and discuss the outcomes of this methodology. Section 6 presents the way in which we have estimated the fixed costs that foreign exporting firms incur when faced with data regulation. In Sections 7 and 8, we calculate how data regulations affect investment and R&D activities as a consequence of data regulation. The last section concludes and gives some policy insights.

2. RELATED LITERATURE

Not much research that evaluates the economic effects of data processing services or the impact of regulations in this field has yet been carried out. Although this lack of research can be explained by the fact that regulation in this sector is a relatively new development, for many firms, data processing services nonetheless form an important part of their daily activities and investments. An early paper by Jorgensen *et al*. (2010) illustrates how important data as an input can be for other downstream sectors. It shows that information technology (IT) capital as part of an industry's total capital input use, under which data processing is included, can take up a relatively large proportion.[1] For instance, various services sectors such as air transportation or broadcasting and telecommunications, but also machinery are characterised by a large share of IT-capital input.

Moreover, using US economic growth figures Jorgenson *et al*. (2010) show that after 1995, IT-capital input was by far the biggest source of economic output growth. This feature is also reflected in macro-economic productivity figures in which IT-producing industries together with IT-using industries contributed most to the aggregate productivity growth over time. Together these results show that data processing and data-related services as part of IT investments are an important determinant of the economic performance of industries and firms that use data.

Nonetheless, the information and data processing sector has gained increased attention from researchers not only because of its positive economic impact, but also because of new regulations that

1. In their study, capital input coming from IT-capital and IT-services is comprised of (i) information and data processing services, (ii) computer system design as well as (iii) the IT-producing hardware industries such as computers, communications equipment and semiconductors. Industries which are intense in using IT are defined as having a higher median share of 15.4 percent (in 2005) of capital input sourced from IT-capital and services.

have been developed. One notable example is the European Union's (EU) General Data Protection Regulation (GDPR) which has generated interest from both the academic and policy community. Christensen *et al*. (2013) evaluate the impact of this proposal on small- and medium-sized enterprises (SMEs) and conclude that SMEs which use information rather intensively are likely to incur substantial costs in complying with these new rules on data processing. The authors compute this result by using a simulated dynamic stochastic general equilibrium model and show that these firm-specific costs will have a significant adverse impact on job growth and business creation. More specifically, the amount of jobs that would disappear as a consequence of the GDPR ranges between 100,000 in the short run to more than 300,000 in the long run.[2]

In addition, using a computable general equilibrium GTAP model, a study by ECIPE (2013) estimates the GDP impact of the EU's proposed GDPR as a consequence of reduced trade between EU economies and the rest of the world. The magnitude of these trade frictions is estimated by developing three scenarios in which data processing companies are hurt. For instance, a serious disruption of trade and cross-border data flows caused by the GDPR could have a negative impact in a range between 0.8 to 1.3 percent of EU GDP. Both goods and services industries would be hurt since both sectors use data information services as inputs. This study follows a similar approach by applying the data input intensities for each downstream sector in the domestic economy in order to calculate the costs for domestic firms as well as foreign exporting firms.

Overall, there has not been much empirical research in this field that measures the economic effects of data processing regulation. Moreover, the few existing studies have focused on the average effect of data regulation for the economy as a whole. Currently no study exists that aims to explore how the costs of data processing regulations are reflected in lower GDP or TFP growth figures. To the knowledge of the authors, this study is the first analysis trying to clarify the channels through which data regulation has an impact on the economy across various downstream sectors. Put differently, this study investigates how increased regulation in data processing translates into lower levels of economic performance and higher costs for the downstream users employing data processing services as part of their input selection.

3. EMPIRICAL STRATEGY

In this section, we explore how data processing regulation is systematically related to the performance of downstream manufacturing and services industries inside an economy. To do so, we will apply an identification strategy which uses information on (a) the extent to which data processing regulation is present in various countries, (b) the performance of downstream industries in each of the countries selected in our data set, plus (c) a measure that links our data processing index to downstream industry performance.

3.1. Cost Price Increases of Data Regulation for Domestic Firms

Since no composite index currently exists that measures the extent to which data processing industries are regulated, we rely on an indirect measure in order to obtain a sound proxy indicator.

2. The authors state that most of these costs will be felt due to firms which are obliged to designate a data processing officer (DPO) together with the development of a data management system. The former is treated as a fixed cost and applies to firms employing more than 250 employees or where data processing belongs to the core activities of the firm. The latter are treated as variables costs. Sectors such as real estate and business services are most affected by this regulation.

This proxy index should roughly reflect the regulations currently in place in selected countries' data processing and related data services sectors. To undertake such an exercise, we first select which sectors require data processing and related services. A list of these sectors is given in Table 1 and is largely based on the so-called IT-producing sectors put forward in Jorgenson *et al*. (2005; 2007; 2010). The only difference is that sectors which are not included in our selection are the IT equipment manufacturing sectors, which are goods industries.[3] The selection of sectors has been done by an expert group that worked closely with data services companies and representatives.

To develop our proxy index, we undertake a two-step procedure. First, we verify across a selected group of countries that are currently considering data regulation measures, of the respective regulations concerning data processing services which currently exist or are being considered, i.e. what regulatory measures are observable at the moment in most of the data services sectors listed in Table 1. Based on the assessment of the current regulatory barriers, we create three types of proxies for the existing barriers in sectors that use data processing intensively. Second, a so-called typology is constructed that uses current indicators of regulation as part of the integrated structure of the OECD's Product Market Regulation (PMR) in services, which can be found in Figure 1. In other words, within this PMR composition scheme, we select several sub-indicators which should measure as close as possible the type of prevailing regulatory barriers in the data services sectors listed in Table 1. By doing so, we rely on the information we have on the types of regulations and market structure in these sectors in several countries under study.[4]

In an attempt to be as complete as possible and to make sure we capture the right type of regulation in data services we select several different sub-indicators of the PMR together and create three different types of indexes:

1. In the first index we only select the administrative regulations of professional services, which in the PMR structure falls under the division 'Barriers to entrepreneurship' and is made up of a simple average between two indicators measuring administrative barriers in services. We take this index for two reasons. First, most of the services using data processing as listed in Table 1 are professional services according to the NAICS (North American Industry Classification System) in which these barriers are, to a large extent, applicable. Second, most of the regulatory barriers observed in these sectors are of an administrative nature (see Table 2). Hence, by selecting the administrative barriers to firms we try to capture at least some of the regulatory burdens that also prevail in data services.
2. The second index also looks at regulatory barriers that go beyond administrative procedures and burdens by, in addition, selecting sub-divisions from other sections of the PMR structure. Specifically, we select the indicator 'Involvement into business operations' under the 'State Control' section, together with the indicators reflecting the 'Complexity of Regulatory Procedures' and again the 'Administrative Burdens for establishment' under the 'Barriers to Entrepreneurship' section. An unweighted average is taken across these three indicators for constructing this second index.
3. Finally, we take the general PMR index for a robustness check to verify whether we

3. These industries are the following as illustrated in Jorgenson *et al. (2010): Computer and peripheral equipment manufacturing; Communications equipment manufacturing; and Semiconductor and other electronic component manufacturing.*

4. The countries selected for analysis of the prevailing (or considered) regulatory barriers in data services are the EU, Brazil, China, Vietnam, Indonesia, Korea, Russia and India.

captured those specific types of regulatory barriers in data services which do not correlate too much with the overall PMR index. It may be the case that not much variation exists between the overall PMR measures and the two different proxies we create under (1) and (2). If so, we would expect that this latter general PMR indicator will have as much explanatory power on our dependent variables as the former ones.

3.2. Downstream linkage

The next question to address is how to connect these indexes of regulation to all other data input using sectors in the economy since an unweighted regulatory impact would not be sufficient to properly capture its downstream effect on our output variable. Hence, to finalise our identification strategy, we link our index of regulation, which is available at country-level, to each individual data-using sector in the economy in our dataset before measuring its impact on the economy-wide output performance.

To do so, we calculate the data services intensity for each industry and services sector in an economy using input-output use tables from the U.S. Bureau of Economic Analysis (BEA). The reason for selecting this approach is that regulation in data services will be most felt in industries and services sectors that actually use data processing and data-related services most intensively as inputs for the production process of other goods and services. Put differently, the input range of the data services is likely to be more important for some manufacturing and services industries than others.

In order to obtain information on the intensity of data services for each industry and services sector, we calculate the proportion of input use of the sectors listed in Table 1 for each industry. This is done by using the US input-output table at 6-digit level which is converted into the NAICS classifications system. For our purposes, these intensities at NAICS level are then reclassified into the GTAP sectoral classification for which the calculated intensities are shown in Table 3. One can see that services such as Telecommunications, ICT Business services, together with Finance and Insurance are sectors which use data input services most intensely whereas the Processing Food and the Metals industry, plus Primary Agriculture are sectors where data services play only a negligible role.

Having calculated these two types of information on both data services reform and data processing intensities for both the goods and services industry, we now link the two data variables into one indicator so that we obtain the following weighted index for data processing services regulation (DPI), namely:

$$DPI_{oit} = \sum_k \alpha_{ik} \; regulation\ index_{ot} \qquad (1)$$

where *DPI* stands for the Data Processing Index for sector *i* in a typical country *o* in year *t*, which is measured by the proportion α_{ik} of inputs sources by both the manufacturing and other services sectors i from data processing services sectors k, multiplied with the data services regulation index for each country *o* in year *t*. Again, the variable α_{ik} is sector-specific and calculated using the US input-output use tables whilst the regulation $index_{ot}$ variable is computed in three different cases using the PMR structure as previously explained. Although our measure of reform starts in year 1998, the data taken from the input-output tables are from year 2002 and it could therefore be that industries with high TFP levels have pushed for regulatory reform. Yet, we are not too much concerned with a potential endogeneity problem since our measure of input proportion is an average percentage for intermediate years of when reform was measured. However, we will deal with the possibility of endogeneity in the next section.

3.3. Measuring the Performance of the Economy

Finally, our last step is to measure the extent to which the regulations introduced in the data services sectors have an effect on the performance of the whole economy through downstream users of data processing services as outlined in equation (1). To take stock of the economy-wide output performance and price effects, we study two different variables which are inversely related to each other, namely Total Factor Productivity (TFP) and a price index based on value added calculations (Pva). Thus, we arrive at the following estimation equations:

$$TFP_{oit} = \alpha_i + \beta_1 DPI_{oit} + \gamma_o + \delta_i + \zeta_t + \varepsilon_{oit} \quad (2a)$$

$$Pva_{oit} = \alpha_i + \beta_1 DPI_{oit} + \gamma_o + \delta_i + \zeta_t + \varepsilon_{oit} \quad (2b)$$

where *TFP* and *Pva* in industry *i* in country *o* in year *t* is explained by the data processing indicator for that same industry *i* in country *o* in year t in both equation (2a) and (2b). In both equations, the terms δ_o, γ_i, and ζ_t stand for the fixed effect by country, sector and year respectively, which we also include in the empirical model. Data for both TFP and prices are taken from the EUKLEMS database which covers information for 2-digit sectors based on the NACE classification and are calculated on a value-added basis. We match this industry classification system with the GTAP classification scheme which we have used for our DPI variable. This is done manually without any concordance tables since both classification systems show high overlap. Finally, both equations' error term is given by ε_{oit}. All together we have a small panel data set for three years covering 21 goods and services sectors for 12 countries.

4. RESULTS

Table 4 provides the results of our regressions divided into the three cases where we make use of the alternative sub-indexes as explained in Section 3.1. In our first setting where we only use the administrative regulatory burdens in professional services, given by DPI (1) in the table, we see that the coefficients have the expected negative sign on TFP and positive sign on value-added prices. Both coefficient results are statistically significant. The results suggests that administrative regulatory barriers in sectors using data processing services most intensively will have a dampening effect on TFP whilst also exerting and upward pressure on prices in these sectors. A one standard-deviation change in our DPI (1) variable would decrease TFP on average by 3.9 percent. Similarly for prices, a one standard-deviation change in the DPI (1) would increase prices on average by 5.3 percent.

In our second and third setting, with variables DPI (2) and DPI (3), the results show a similar impact and coefficient signs pointing to the expected direction. Therefore, when using the alternative sub-index compositions we are now taking into account some of the additional regulatory barriers. The effect on TFP remains negative and statistically significant at the 10 percent level whereas the outcome on prices is still positive and highly statistically significant. The coefficient sizes do not change dramatically although they are slightly lower than when using the regulatory index under DPI (1).

When we enter the overall indicator under DPI (3) however, the result on TFP becomes irrelevant although the effect on prices stays positive and significant albeit at a slightly lower level. The fact that this result becomes economically less important gives us enough confidence that we are indeed capturing a specific type of regulation (i.e. administrative barriers), which are most likely to be important for the data processing services. In other words, taking the overall PMR indicator as measured with DPI (3) may therefore be too generic to enable us to really develop a proxy measure on regulations in data services which would then have a knock-on effect in the data-intensive industries. Thus we would like to stick to DPI (1) or DPI (2) in our subsequent analysis.

In Table 5, we illustrate the results of an additional regression analysis, this time by applying a lag on our explanatory variables. The reason for doing so is that we aim to take further stock of a potential endogeneity concern which could be present as a result of the fact that sectors experiencing higher TFP are the ones lobbying for lower regulation.[5] Taking the lags on our regulatory variables would be a simple way to correct for this channel of endogeneity. In Table 5, we see that all coefficients have the expected sign and are statistically significant, even when taking the overall PMR indicator in the last two columns. The sizes of all coefficients are actually somewhat bigger than obtained in Table 4, but economically this effect is only marginally important. For instance, one standard deviation change in the lagged DPI (1) would increase prices in the economy on average by 6 percent compared to the 5.3 percent found in the previous analysis.

5. APPLICATION OF COST PRICE INCREASES OF DATA REGULATION

Based on our econometric exercise, in the next step we perform a counterfactual analysis for various countries, which eventually will be used for a general computable equilibrium model assessing the welfare impacts of data processing regulations. For our research purposes we select various emerging market economies, plus South Korea and the European Union, for the counterfactual analysis. We do so in order take into consideration the data processing services regulation laws currently in consideration (see Table 6).

5.1. Quantification Process

To perform our computations we rely again on the index of administrative barriers in professional services as part of the PMR structure which we have used in the previous section to come up with our coefficient estimates. Whereas the index of administrative barriers was pre-defined and constructed as part of the OECD's PMR database. This time however we augment this index with actual observed administrative barriers in data processing services. We do this for our selection of countries.

To be more precise, in our econometric analysis in Section 3.1 we selected two indices as defined under scenario (1), i.e. DPI (1), which picked up the administrative barriers in a number of services sectors across OECD and emerging market economies. This time however we supplement this existing index with an additional third indicator that takes stock of the actual newly introduced administrative barriers in data services. The way to do this is to analyse and quantify the proposed data regulation laws currently in deliberation in the aforementioned countries as presented in Table 6 in exactly the same way as has been done for the original index of administrative barriers as part of the PMR structure.

Hence, we begin by selecting those data processing regulatory barriers which (a) our selected

5. Rather than assuming that regulatory policy in data services affects downstream TFP in the wider economy, by taking stock of this potential endogeneity we would like to exclude any reversed causality, i.e. firms which already perform well in terms of TFP are the ones lobbying for precisely lower regulatory barriers. Taking the lag on our independent variables shifts the time-frame backwards so that this possibility of lobbying is ruled out as firms cannot influence policy that took place in previous years.

countries have in common across their proposed law programmes; and (b) have a significant cost burden for firms. This selection has been carried out in close contact with experts in the field. Our final selection of the barriers is presented in Table 2. In this selection process we aim to include measures that have an economically important weight only. Therefore, to assess whether these various barriers would carry along significant costs for services providers we rely on various secondary sources such as Christensen *et al.* (2013), LeMerle e*t al*. (2012), UK MoJ (2012), PwC (2013) and EC(2012) which gives us information about the cost burden of the various regulatory policies.

With our selection of the regulatory barriers at hand, we apply appropriate weights for each regulatory measure and type of restriction so as to take into account the relative importance of each policy measure in the economy. The applied weights are also based on the cost findings in these reports and are shown in Table 7. It turns out that a substantial weight has been put on the data localisation measure, which in our view is the most important regulatory barrier in data services. However, other measures matter too and weights are applied accordingly. Within our second category of barriers we apply high weights on both measures on the right to review and notification breaches.

Eventually, based on our coding scheme and the application of weights we derive a new index that ranges between 0 and 6 for each of our selected countries. The results for each country are given in Table 8. The highest index can be found for the EU (4.55) followed by Korea (4.17) and China (2.97). Brazil (1.08), India (0.8), and Vietnam (0.56) have relatively low index levels of data processing restrictions. Note that this is in large part due to the fact that we put a high weight on the barrier of data services localisation in our methodology. Having this type of barrier in place explains hence the relatively high score for Korea whereas the EU this as well as other administrative barriers in place.

5.2. Augmenting the Index for Administrative Barriers

Our next step is to augment the existing index of administrative barriers in professional services with our index created for administrative barriers in data processing services. To do so we begin by distinguishing between two periods of time, namely one where these data services barriers have not been put in place (t=0) as per today, and a hypothetical situation in which the data processing laws are implemented (t+1), i.e. the initial index is augmented with the index created in Table 8. In t=0, we apply a weighted average of both administrative barriers indices as defined in scenario (1) in Section 3.1, plus an assumed index set to zero for administrative barriers in data processing services which were not implemented yet in time t-1. In period t+1 we compute a weighted average of the administrative barriers as defined under Section 3.1 and the index obtained in Table 8 instead of zero. For both periods of time the weighted average is chosen in such way as to take account of the size of the data services sector in the whole economy.

Table 9 shows the results for both time periods. Unsurprisingly, the highest increase in the index can be observed for China, Korea and the EU. The lowest movement between the two time periods is found for Brazil. Again, this is in large part because Brazil has not implemented laws related to data localisation in addition to some of the other barriers receiving high weights in our methodology.

5.3. Calculating TFP losses

Finally, we are able to calculate the potential TFP losses as a consequence of the hypothetical situation in which countries are truly implementing their regulatory law programmes on data services. We therefore use the indices in both time periods and plug these figures into equation (2a) so that two different TFP levels are obtained: one before the implementation of data laws (t=0) and one after (t+1). For our TFP calculations using equation (2a) we apply the coefficient results as found in Tables 4 and 5 (i.e.), information on the data processing intensities as presented in Table 3, plus the fixed effects by sector which are acquired from running our regressions. The coefficient we chose is from Table 4 under DPI (1), i.e. 2.55, because it is statistically significant and the size of the estimate is most conservative compared to the other variables under DPI (2) and DPI (3) in both Tables 4 and 5. After plugging in our data and calculating the ln(TFP) for both periods, we obtain the percentage change in TFP from taking the first difference of ln(TFP)t+1 and ln(TFP)t=0.

The results of our estimated TFP losses are presented in Table 10. The sectors are sorted by the size of the TFP reduction. As one can see, the Communication sector experiences greatest losses since the effect in this sector is most likely caused by its high dependency on data services input use. For instance, in Korea, China and the EU the percentage TFP losses are estimated to be around 2 percent in Communications. Similarly, both the ICT business services sector and the Finance and Insurance sector also experience relatively high TFP losses of around 0.34 percent in China. Machinery is a merchandise sector in the ranking in which relatively high TFP losses would take place. At the bottom of the list are the Other primary agricultural sector and the Processed foods industry with only minor TFP losses. Their input dependency on data services is likely to be very small. Overall, the results show that it is mostly services sectors that will suffer from regulations in data services.

6. COST PRICE INCREASES OF DATA REGULATION FOR FOREIGN FIRMS

In addition to productivity effects, we are also interested in the cost effects as a consequence of data services regulation (i.e. data localisation) on foreign firms for our selected economies. In this section, we therefore explore if data processing regulation is systematically related to the performance of downstream manufacturing and services industries inside the economy through the provision of data services by foreign providers. To do so, we use the data on the upfront investment and operational costs a foreign firm faces and needs to incur when exporting to the host economy by setting up a data centre in one of the seven countries analysed in this study.

The information to estimate the cost differences between countries as a result of data localisation regulation in each of the countries are extracted from two sources, namely the Data Centre Risk Index (2013) and Frost and Sullivan (2012). The former work investigates all the risk factors associated with the costs of setting up and operating a data centre in various economies around the world. As such, it ranks countries along these risk determinants which are, amongst others, the costs of labour, the quality of international internal bandwidth, the cost of energy. Various additional factors such as the educational level of the countries, political stability and inflation risks are taken into account in the index. All the determinants affecting the cost of data centres closely follow the general cost structure of doing business across countries. In this report the US ranks as first having the highest index score whereas Brazil has the lowest ranking meaning that costs are highest in this country for foreign firms when operating a data centre.

The latter source provides us comparative information on the precise cost of building a data infrastructure in several countries which are mentioned in the Data Centre Risk Index such as Brazil, Mexico and the US. Assuming that the US is most competitive in terms of setting up a data centre and Brazil has the highest absolute costs structure, as the Frost and Sullivan report shows, we are able to infer the relative cost structure of building a data risk centre for all countries in our sample compared to the US. The result of this exercise is shown in Table 11 and shows that, for instance, Brazil is 56 percent more expensive in terms of costs of setting up a centre relative to the US; Indonesia is around 52 percent more expensive whilst Korea is around 23 percent more expensive.

Most intermediate countries are from the EU where the cost differences range between 4 percent in the case of Great Britain to 41 percent for the Czech Republic.

Next, we multiply this number for each country with the intensities on data processing services in order to obtain a rough estimate about the cost differences across sectors for each country. Put formally, we obtain a weighted index by country-sector for cost price increases as a consequence of a data localisation index (DLI) requirement for the foreign firm as follows:

$$DLI_{oi} = \alpha_{ik} \text{ relative cost difference}_{o} \tag{2b}$$

where *DLI* stands for the cost price of the data localisation index for sector *i* in a typical country *o*, which is again measured by the proportion α_{ik} of input sources by both the manufacturing and other services sectors sector *i* from data processing services sectors *k*, multiplied with the information on the relative upfront investment costs firms need to undertake when investing in each country o. In equation (4) the variable α_{ik} is again sector specific and calculated using the US input-output use tables whilst the $\textit{relative cost difference}_{o}$ variable is computed using the information provided in the last column of Table 11 using the data sources as explained above. Note that our DLI measure is expressed in terms of proportions as the costs are expressed as relative to the US.

The percentage increases as a result of data regulations for foreign firms are presented in Table 12 for each country and sector analysed in this study. As expected, the cost price increases for the EU and Korea are less pronounced compared to countries such as Indonesia or China where the cost of investing in a data processing centre is much higher. Moreover, we see that the Business services sectors are heavily affected across all countries. This is not a surprise since these sectors use data services most intensively. Our results on the costs of data localisation and cost effects of data services regulations can now be implemented in a GTAP analysis as performed in the ECIPE study.

7. COST OF INVESTMENT AS A RESULT OF DATA REGULATION

Investments are a major driver for economic growth in particular for developing countries. Since a tighter regulatory environment generally imposes costly market limitations, investments of both domestic and foreign entities decreases, which we account for by utilising GTAP's investment approach.

GTAP is a pure 'real goods model' that does not account for financial instruments. Thus, the standard GTAP model does not take into consideration supply-side impacts of capital market conditions. In the model, investors are represented by a global bank allocating regional savings and investments around the world. Investment itself is represented by a stock of 'capital goods' (CGDS), which is treated as a commodity that is purchased by the global bank and allocated to regions (countries) following a return-equalising rule. The capital goods commodity does not employ any primary factors of production. It rather absorbs a mix of intermediate goods such as construction, machinery equipment, vehicles, and services, etc. In addition, capital goods cannot be traded across regions. Instead, regional capital goods' formation is determined be regional savings, which are absorbed by the global bank and reallocated to regions thereafter.

In order to estimate the economic impact of decreasing returns on capital due to data localisation barriers to trade, we follow an indirect expected rate of return approach. It is assumed that the global bank allocates investment across regions in such a way that risk-adjusted rates of returns are equalised across regions. Thus, in GTAP a change of the expected rate of return in a given region results in corresponding changes in the amount of regional investment. The underlying assumption is that equilibrium rates of returns on investment are equal across regions and equal to a global rate of return. In addition, it is assumed that expected returns in a specific region will fall as the amount of investment rises. Thus, a difference between the global rate of return and a region's rate of return triggers a reallocation of investment across regions until regional rates of investment are equalised again. The difference between risk-adjusted regional rates of return can be read as a region-specific risk premium decreasing the region's attractiveness to investors. In line with this assumption, an increase in regional investment risk reduces capital goods formation and decreases demand for factor inputs to investment in the region concerned. At the same time, investment would increase in regions not affected by decreasing investor appetite.

The underlying idea of modelling investment in this study is based on a set of assumptions. As a starting point, we apply numbers resulting from a comprehensive study of McKinsey (2011), which is analysing the use of big data and its impact on innovation, investment, competition and productivity. According to this study, the use of big data effectively reduces working capital in manufacturing by 3 to 7 percent. We further assume that this percentage reduction is normally distributed, i.e. on average, working capital in manufacturing is reduced by 5 percent due to use of big data.

Due to higher costs, data localisation regulation is assumed to exert a negative impact on the supply big data services. We also assume that the use of big data is still possible though restricted and/or more expensive due to lower supply of big data services. Accordingly, firms engaged in manufacturing cannot fully benefit from the efficiency gains resulting from the availability of big data services in general. Therefore, we assume that working capital in manufacturing is reduced by 2.5 percent, which corresponds to a 2.564 percent decrease in return on (working) capital investment in manufacturing. Next, we assume that the percentage change of sector-specific return on investment is proportional to the share of data processing in all other sectors under study, which results in the 'share of data processing adjusted decrease in ROI'.

Finally, the share of data processing adjusted decrease in ROI is adjusted by the sector size to GDP ratio of a given country, which emerges in the final 'sector-specific decrease in ROI'. In sum, these numbers amount to a single country-specific decrease in ROI, which is 2.8 percent for Brazil, 2.3 percent for China, 2.4 percent for India, 2.2 percent for Indonesia, 2.7 percent for South Korea, and 1.9 percent for Vietnam.

The results of modelling investment only have indicative character, meaning that we are not able to forecast the precise investment effect due to data localisation barriers to trade mainly for two reasons: 1) The shortcomings in the treatment of investment in GTAP and 2) the transformation of expected return on investment into investor risk appetite, which is an empirical problem in general. Yet, the methodology we apply allows us to forecast and trace the direction of investment flows.

8. LOWER RETURNS FROM R&D AS A RESULT OF DATA REGULATION

Another loss of ROI occurs also from lesser efficiency in R&D. This effect is due to the use of customer data in developing and adapting new products and services. There are industry estimates that show 51percent of firms use customer relationship management (CRM) application suites for data mining of their customer base for marketing and product development purposes (Computer Economics, 2011). However, the number of firms using electronically collected data in their business processes ought to vary significantly between different economies depending on the level of technological development and ICT usage amongst the population. A comparative survey by Xu, Zhu, Gibbs (2004) shows that 48 percent of firms in the US (based on a mean of firms that use online sales, electronic data interchanges (EDI) or online advertising) therefore possess and process customer data in some form, whereas the equivalent share is 29 percent in China. These two observations serve as values for number of firms using personal data in R&D on their products, services and customer interaction in developed economies and developing economies respectively. The numbers is also in line with the aforementioned share of firms using CRM.

The relation between R&D expenditure and returns is the subject of several empirical studies, notably Hall, Foray, Mairesse (2009); Ortega, Argilés (2009); Rogers (2009). Amongst these (Table 13), Hall, Foray, Mairesse (2009) provides the most conservative estimate, which is also based on the largest and most recent dataset. It may be argued that there are uncertainties in using returns of R&D investments of an economy such as the US with a very high level of productivity. However, the returns from the use of advanced software ought to be more constant than traditional base research, and the numbers are also weighted by the return rate from R&D in the economy as well as the share of firms deploying such technologies in their business processes as per above. The resulting reduction of ROI weighted by these factors is presented in Table 14. However, it should be noted that these ROI losses are marginal relative to the ROI losses on investment.

9. CONCLUSIONS

This paper forms a background paper describing the methodology used in the ECIPE Occasional Paper, 'The Costs of Data Localisation: A Friendly Fire on Economic Recovery', which assess the welfare implications as a result of tighter data regulations.

In this paper, two channels of economic costs are taken into account. The first channel is a domestic one in which the domestic firm is faced with data regulation which increases the data service provided to downstream users inside the country. To estimate these costs, we have carefully mapped all regulatory restrictions currently considered in various countries and consequently have expressed their associated costs in terms of TFP losses for the economies under study.

The second channel through which we assess the costs of data regulation is by assessing the upfront and operating costs a foreign firm faces when setting up a data centre inside the economy where it would like or is forced to deliver data services. This estimate is closely assessing the data localisation requirement for external firms as opposed to domestic firms. Our estimates show that these costs can also be considerable across various sectors inside the economy, i.e. on downstream users using data services as inputs.

Together the findings show that regulations on the free flow of data have a significant impact on the overall economy. Domestic as well as foreign firms will have to incur the costs related to the regulatory policies, which eventually results in higher prices of goods and services for domestic consumers.

TABLES AND FIGURES

TABLE 1: SELECTED SECTORS RELATED TO DATA PROCESSING SERVICES

NAICS 6-digit sector	Description
511140, 511190	Directory, mailing list, and other publishers
511210	Software publishers
516000	Internet publishing and broadcasting
517000	Telecommunications
518100	Internet service providers and web search portals
518200	Data processing, hosting, and related services
519000	Other information services
541511	Custom computer programming services
541512	Computer system design services
541513, 541519	Other computer related services, including facilities management

Source: Bureau of Economic Analysis (BEA)

TABLE 2: TYPES OF REGULATORY BARRIERS IN DATA PROCESSING SERVICES

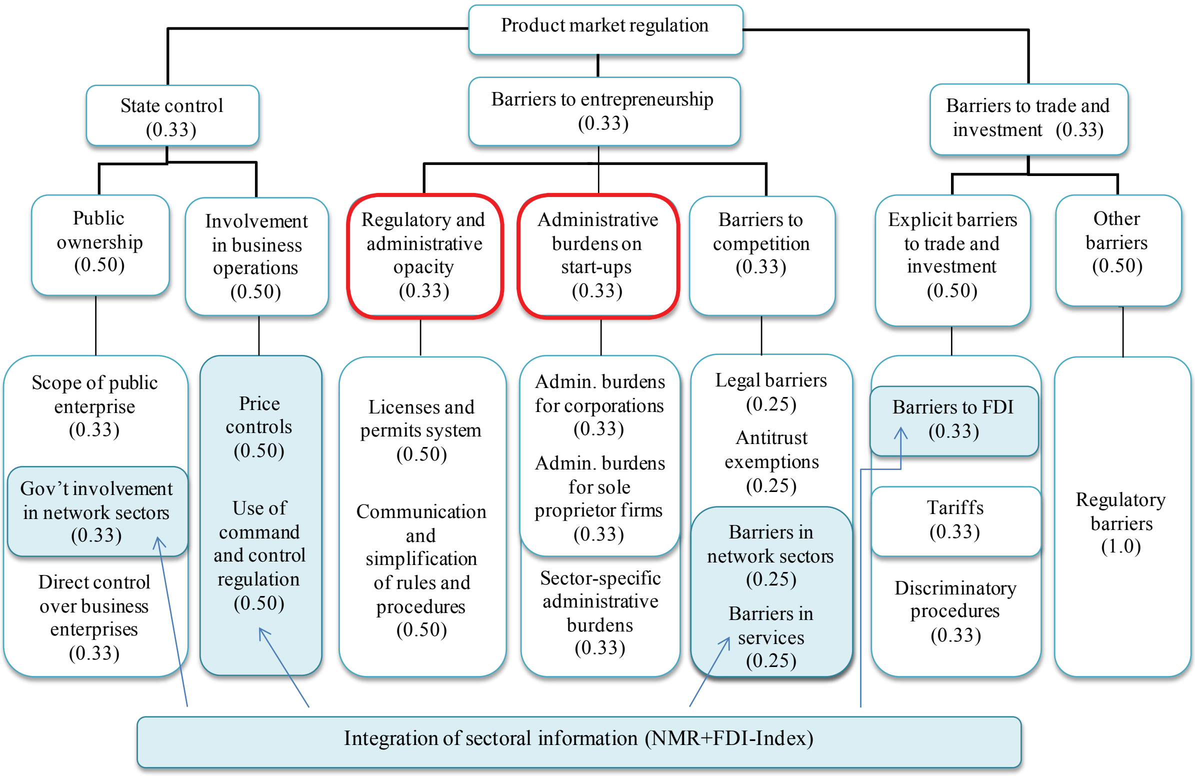
Type of restriction	Regulatory measure	Outcome
Restrictions related to the foreign supply of data services	Is there a data localisation requirement?	Yes / Limited / No
Restrictions related to internal productivity losses / admin costs	Is there a strict consent requirement for the collection, storage, dissemination of personal data?	Yes / No
	Does the law provide users with the right to review their stored information?	Yes / No
	Does the law provide users with the right to be forgotten/ deleted?	Yes / No
	Is a notification of breaches towards the government/user obligatory?	Towards government / user / government & user
	Are data protection impact assessments obligatory?	Yes / No
	Is a data protection officer required?	Yes / No / Qualified Yes
	Are there administrative sanctions for non-compliance? How high?	Varies according to height of sanctions
	Does the government require easy access to companies' data?	Yes / No
	Are companies required to retain data for a fixed period of time?	Yes / No

TABLE 3: DATA PROCESSING INTENSITIES

GTAP sector	Sector description	Data processing intensity
communication	Post and Telecommunication services	0.318
obsict	Other Business and ICT services	0.069
fininsurance	Financial and Insurance services	0.050
machinery	Machinery and Electronic equipment	0.049
oconsumer	Other Consumer services	0.048
oservices	Public services, dwellings	0.040
distribution	Trade and Distribution services	0.037
water	Water and other Utility services	0.034
transport	Transport services	0.032
construction	Construction	0.024
othermanuf	Manufactures nec.	0.024
fabmetals	Metal products	0.020
nonmetmin	Mineral products nec.	0.014
lumberpaper	Wood and Paper products	0.014
energy	Coal, Petroleum and Gas production	0.011
transequip	Motor vehicles and parts	0.008
chemicals	Chemicals, Rubber and Plastic Products	0.008
bevtextcloth	Beverages/tobacco products; Clothing and leather products	0.007
metals	Ferrous metals and Metals nec.	0.007
primagrother	Primary agricultural products	0.007
procfoods	Meat, Vegetable oils, Dairy, Sugar and Food products nec.	0.006

Source: Author's calculations using BEA

FIGURE 1: TREE-STRUCTURE OF THE INTEGRATED PRODUCT MARKET REGULATION INDICATOR



Source: OECD Product Market Regulations

TABLE 4: REGRESSION RESULTS ON PRICES AND TFP

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	TFP	PRICE	TFP	PRICE	TFP	PRICE
DPI (1)	-0.255**	0.395***				
	(0.122)	(0.108)				
DPI (2)			-0.197*	0.366***		
			(0.117)	(0.124)		
DPI (3)					-0.347	0.587**
					(0.233)	(0.239)
Observations	996	1,002	828	834	828	834
R-squared	0.159	0.173	0.200	0.188	0.200	0.187
RMSE	0.164	0.187	0.164	0.191	0.164	0.191

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

TABLE 5: REGRESSION RESULTS ON PRICES AND TFP (LAGGED)

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	TFP	PRICE	TFP	PRICE	TFP	PRICE
DPI (1)	-0.269**	0.444***				
	(0.119)	(0.106)				
DPI (2)			-0.245**	0.385***		
			(0.120)	(0.112)		
DPI (3)					-0.414*	0.660***
					(0.231)	(0.220)
Observations	996	1,002	828	834	828	834
R-squared	0.113	0.235	0.135	0.244	0.135	0.245
RMSE	0.165	0.180	0.169	0.184	0.169	0.184

Robust standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$

TABLE 6: SELECTED ECONOMIES WITH THEIR LAW PROPOSALS FOR DATA PROCESSING

Country	**Title law for data processing barriers**
Brazil	Marco Civil
Vietnam	Decree 72
Indonesia	GR 98 (2012) and EIT Law (2008)
China	Decision on Strengthening the Protection of Information on the Internet (December 2012) and Telecommunication and Internet User's Personal Information Protection Measures (September 2013) + Consumer Protection Law amendment of April 2013
India	Data retention provision of IT act + proposed National Security Council Secretariat strategy on cyber security + proposed licen-sing requirement by Dept. of Telecom
South Korea	Personal Information Protection Act (PIPA)
European Union (EU)	EU General Data Protection Regulation (GDPR)

TABLE 7: QUANTIFICATION OF PROPOSED DATA PROCESSING BARRIERS

	Weights by theme (bj)	Question weights (ck)	Coding of outcome data		
Foreign supply of data services:	**0.3**		**No**	**Limited**	**Yes**
Is there a data localisation requirement?		1	0	3	6
Internal admin costs measures:	**0.7**				
			No		**Yes**
Is there a strict consent requirement for the collection, storage and dissemination of personal data?		0.050	0		6
Does the law provide users with the right to review their stored information?		0.500	0		6
Does the law provide users with the right to be forgotten, deleted?		0.047	0		6
			No	**Govt or user**	**Both**
Is notification of breaches towards the government and / or users obligatory?		0.200	0	3	6
			No		**Yes**
Are data protection impact assessments obligatory?		0.175	0		6
Is a data protection officer required?		0.375	0		6
			No	**Some**	**High**
Are there administrative sanctions for non-compliance? How much?		0.047	0	3	6
			No		**Yes**
Does the government require easy access to companies' data?		0.047	0		6
Are firms required to retain data for a fixed period of time?		0.013	0		6
Country scores (0-6)	$\sum_{j}(_{bj}) \sum_{k}(_{ck})$ answer$_{jk}$				

Note: Question weights are based on Christensen (2013) and UK Ministry of Justice (2012)

TABLE 8: INDEX OUTCOMES OF THE QUANTIFICATION METHOD

	Brazil	China	India	Indo'ia	Korea	EU	Vietnam
Foreign supply of data services:							
Is there a data localisation requirement?	0	6	6	6	3	0	6
Internal admin costs measures:							
Is there a strict consent requirement for the collection, storage and dissemination of personal data?	6	6	6	3	6	3	0
Does the law provide users with the right to review their stored information?	0	0	0	6	6	6	0
Does the law provide users with the right to be forgotten, deleted?	6	6	0	0	6	6	6
Is notification of breaches towards the government and / or users obligatory?	0	6	0	3	6	3	0
Are data protection impact assessments obligatory?	0	6	0	0	0	6	0
Is a data protection officer required?	0	0	0	0	6	6	0
Are there administrative sanctions for non-compliance? How much?	6	3	3	3	3	3	0
Does the government require easy access to companies' data?	3	0	6	0	0	0	6
Are firms required to retain data for a fixed period of time?	6	0	6	0	0	6	0
Country scores (0-6)	1.08	2.97	0.80	0.89	4.17	4.55	0.56

TABLE 9: INDEX MOVEMENTS BETWEEN PERIOD (T=0) AND (T+1) FOR AUGMENTED INDEX

	Index (t=0)	**Index (t+1)**
Brazil	0.58	0.65
China	0.78	0.98
India	0.86	0.91
Indonesia	0.24	0.30
Korea	0.21	0.49
EU	0.34	0.65
Vietnam	0.78	0.82

Note: Each time period contains an average of administrative barriers in professional services and data processing services. In t=0 the index for data processing services is set to zero, whereas in t+1 the index for data processing services is set to the level as defined in Table 8 for each selected country. Note that data for Russia's data processing law is currently incomplete.

TABLE 10: TFP LOSES AS A CONSEQUENCE OF DATA PROCESSING REGULATIONS

Sector	Brazil	China	India	Indonesia	Korea	EU	Vietnam
All sectors	**-0.07**	**-0.35**	**-0.22**	**-0.22**	**-0.35**	**-0.29**	**-0.20**
Goods	**-0.02**	**-0.12**	**-0.07**	**-0.08**	**-0.12**	**-0.10**	**-0.07**
Services	**-0.10**	**-0.52**	**-0.32**	**-0.32**	**-0.51**	**-0.43**	**-0.29**
Business services	**-0.17**	**-0.85**	**-0.52**	**-0.53**	**-0.84**	**-0.70**	**-0.48**
communication	-0.42	-2.16	-1.31	-1.35	-2.13	-1.77	-1.22
obsict	-0.09	-0.47	-0.29	-0.29	-0.46	-0.39	-0.27
fininsurance	-0.07	-0.34	-0.21	-0.21	-0.34	-0.28	-0.19
machinery	-0.07	-0.34	-0.20	-0.21	-0.33	-0.28	-0.19
machinery	-0.07	-0.34	-0.20	-0.21	-0.33	-0.28	-0.19
oconsumer	-0.06	-0.33	-0.20	-0.20	-0.32	-0.27	-0.18
oservices	-0.05	-0.27	-0.17	-0.17	-0.27	-0.22	-0.15
distribution	-0.05	-0.25	-0.15	-0.16	-0.25	-0.21	-0.14
water	-0.04	-0.23	-0.14	-0.14	-0.23	-0.19	-0.13
transport	-0.04	-0.22	-0.13	-0.14	-0.22	-0.18	-0.12
construction	-0.03	-0.16	-0.10	-0.10	-0.16	-0.13	-0.09
othermanuf	-0.03	-0.16	-0.10	-0.10	-0.16	-0.13	-0.09
fabmetals	-0.03	-0.14	-0.08	-0.08	-0.13	-0.11	-0.08
nonmetmin	-0.02	-0.10	-0.06	-0.06	-0.10	-0.08	-0.06
lumberpaper	-0.02	-0.09	-0.06	-0.06	-0.09	-0.08	-0.05
energy	-0.01	-0.07	-0.05	-0.05	-0.07	-0.06	-0.04
transequip	-0.01	-0.06	-0.03	-0.04	-0.06	-0.05	-0.03
chemicals	-0.01	-0.06	-0.03	-0.04	-0.06	-0.05	-0.03
bevtextcloth	-0.01	-0.05	-0.03	-0.03	-0.05	-0.04	-0.03
metals	-0.01	-0.05	-0.03	-0.03	-0.05	-0.04	-0.03
primagrother	-0.01	-0.04	-0.03	-0.03	-0.04	-0.04	-0.03
procfoods	-0.01	-0.04	-0.03	-0.03	-0.04	-0.03	-0.02

Note: Sectors follow the GTAP classification.

TABLE 11: RELATIVE ABSOLUTE COST STRUCTURE OF SETTING UP A DATA CENTRE

Country	Data Centre Risk Index (Cushman & Wakefield), 2013		Based on Frost and Sullivan (2012)
	Rank	Index	Relative cost difference
USA	1	100.00	-
GBR	2	89.53	0.02
SWE	3	82.29	0.04
DEU	4	81.29	0.06
FIN	9	78.74	0.16
NLD	12	76.26	0.21
KOR	13	74.59	0.23
FRA	14	73.98	0.25
POL	17	67.43	0.31
IRE	18	67.09	0.33
ESP	21	65.15	0.39
CZE	22	64.14	0.41
CHN	25	58.91	0.47
IDN	28	46.37	0.52
IND	29	40.85	0.54
BRA	30	35.15	0.56

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TABLE 12: COST-PRICE INCREASE AS A CONSEQUENCE OF DATA CENTRE INVESTMENT

GTAP sector	Brazil	China	India	Indonesia	Korea	EU	Russia
All sectors	**7%**	**6%**	**7%**	**7%**	**3%**	**3%**	**6%**
Goods	**2%**	**2%**	**2%**	**2%**	**1%**	**1%**	**2%**
Services	**11%**	**9%**	**11%**	**10%**	**5%**	**5%**	**9%**
Business services	**16%**	**13%**	**15%**	**15%**	**7%**	**7%**	**13%**
communication	21%	17%	20%	20%	9%	9%	17%
obsict	11%	9%	11%	10%	5%	5%	9%
fininsurance	31%	25%	30%	29%	13%	13%	24%
machinery	4%	3%	4%	4%	2%	2%	3%
oconsumer	10%	8%	10%	9%	4%	4%	8%
oservices	11%	9%	11%	11%	5%	5%	9%
distribution	8%	7%	8%	8%	3%	3%	6%
water	3%	3%	3%	3%	1%	1%	2%
transport	12%	10%	12%	11%	5%	5%	10%
construction	3%	2%	2%	2%	1%	1%	2%
othermanuf	3%	3%	3%	3%	1%	1%	3%
fabmetals	3%	3%	3%	3%	1%	1%	3%
nonmetmin	2%	1%	2%	2%	1%	1%	1%
lumberpaper	2%	1%	2%	2%	1%	1%	1%
energy	1%	1%	1%	1%	1%	1%	1%
transequip	1%	1%	1%	1%	1%	1%	1%
chemicals	1%	1%	1%	1%	1%	1%	1%
bevtextcloth	1%	1%	1%	1%	1%	1%	1%
metals	2%	2%	2%	2%	1%	1%	2%
primagrother	1%	0%	1%	1%	0%	0%	0%
procfoods	1%	1%	1%	1%	0%	0%	1%

Note: Sectors follow the GTAP classification.

TABLE 13: COMPARISON OF EMPIRICAL STUDIES OF RETURNS FROM R&D SPENDING

	Return from R&D	Sample, years
Hall, Foray, Mairesse	23%	1513 US firms, 2004-2006
Ortega, Argilés	35%	532 EU firms, 2000-2005
Rogers (manufacturing)	40-58%	719 UK firms, 1989-2000
Rogers (non-manufacturing)	53-108%	719 UK firms, 1989-2000

TABLE 14: ROI LOSSES WEIGHTED BY SPENDING, SHARE OF FIRMS USING PERSONAL DATA IN R&D

	R&D Spending	Return rate from R&D	Share of firms using data for R&D	Reduction in ROI
Brazil	1.16%	23%	29%	0.08%
Korea	3.74%	23%	48%	0.41%
China	1.84%	23%	29%	0.12%
India	0.88%	23%	29%	0.06%
Indonesia	0.08%	23%	29%	0.01%
Vietnam	0.19%	23%	29%	0.01%
EU	2%	23%	48%	0.22%

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