**A STUDY ON THE PRODUCTIVITY AND ECONOMIC PERFORMANCE IN NORTH AMERICA IN THE 2000’s. A MULTISECTOR AND STRUCTURAL PERSPECTIVE**

Fidel Aroche

Marco Antonio Marquez[[1]](#footnote-1)

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Abstract: Growth in the North American economies has converged to a common rate; nevertheless, differences in *per capita* incomes remain. The three economies exchange goods to be employed as inputs in various industries, in such a way that they form a single economic area. This paper explores the productivity differentials by industry in Canada, the US and Mexico employing the concept of vertically integrated sector and the multipliers matrices in connection to labour productivity in each country

Key words: factor productivity, economic structure, vertically integrated sectors, North America

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**Introduction**

Canada and the United States (US), on the one hand and the latter and Mexico have been major trade partners since the XIX Century, which gave way to a process of purposeful integration of those economies around a free trade agreement (NAFTA), enforced since 1994. Nevertheless, differences between these economies have persisted, not only in size, but also in their population welfare, maintaining an asymmetric profile of integration, while there have not existed regional convergence policies or strategies. Besides, the economic relationships between Canada and Mexico continued –in fact- flimsy, if they have grown during some periods. However, the latter economies have undergone significant structural changes in order to adapt to their integration pattern with the US, the economic regional leader, which has kept its structural profile intact.

Differentials in factor productivity between the three partners explain that incomes have remained unequal; i.e., if the economies have become more interdependent, they must have changed their GDP composition, together with their foreign trade patterns, but the production functions in these economies have not converged. Exchange in the region is mainly intraindustrial, as it is between developed countries. That implies that factor productivity ought to be comparable in each industry in each country in North America.

This paper explores the productivity differentials in Canada, the US and Mexico from a structural and multisectoral perspective, using the Input-Output (IO) methodology as a framework. The perspective adopted takes the US economy as a reference. The database derives from the OECD Structural Analysis (STAN) Database, which provides statistical information to analyse the economic performance of 48 of countries at industrial level. The database includes the Input-Output Tables up to years around 2005. The tables for the relevant countries have been put together, giving rise to a regional table that conveys the structural relationships existing between branches and sectors in Canada, the US and Mexico, defined by trade (Marquez, 2012). The rest of the paper contains three sections, the first one explores the important concepts and methods in regards to the study and the implications of sectoral productivity in the IO framework, the second section is devoted to the analysis of the main results in North America; the final one offers a few final considerations.

**Productivity**

Few authors define productivity clearly, despite that there are abundant studies on its evolution in different countries and periods of time. Moreover, there is no consensus on its measurement, maybe reflecting that the concept is not neat either. Productivity refers to some relationships between the quantities of commodities produced and the amount of factors employed in the process; i.e., it is a result of the production function. If different economies employ different technologies, productivity should be different as well. Technical change should also imply that productivity increases in time. Firms should employ decreasing amounts of inputs in order to produce given amounts of outputs, unless such changes were not efficient.

In equilibrium, non-produced inputs (factors) should be rewarded according to their contribution to output, which in turn ought to equal their market price. Factoral income is explained by factoral productivity and comparing different economic systems, a higher income population should also be more productive. The factors they own are therefore employed more efficiently to produce some basket of goods.

Trade between countries reflect their specialization profile, which is also a result of their factor endowments (if the neoclassical theory is correct). Imported inputs are also non-(locally)-produced goods and they can be taken as any other factor, which is not a standard practise. In the limit, if the World economy is efficient, the “pure theory of international trade” would predict that factors employed in different countries should enjoy comparable rewards, as specialization advances, allowing the optimum employment of factors in each industry in each economy. In reality, however, factors receive different incomes in each country and *per capita* incomes in different countries differ, as a result of productivity differences.

The simplest productivity measures relate the output value to the use of each non-produced factor. It is also common to relate value added (VA) or gross domestic product (GDP) to the use of factors in order to measure productivity: output per physical unit of factor employed. The advantage of the latter is that either VA or GDP are easily related to welfare that the population enjoy in a country. These indicators imply that factors are measurable at any point. Factors belong to the population and relative welfare is related to the distribution of that ownership among individuals, together with the amount of available resources and their market price -or remuneration.

Structural analysis understands the economy as a system of interdependent sectors (Leontief, 1937), which produce goods by means of produced goods, combined with factors (non-produced inputs), according to some technology that prescribes the proportions between inputs as well as between inputs and outputs. In the model inputs are produced using produced and non-produced goods, which indirectly are used to produce outputs. Since it is an equilibrium model, such proportions are optimum, but they can be different for different systems; besides the model assumes constant returns to scale, which implies linear relationships between the variables. The basic equation of the open model is (Miller and Blair, 2009):

x = X+ y

*x* is the output vector, *X* is the exchange matrix, is the unit vector and y is the final demand vector. The former is equivalent to:

x = xA + y

where *A = {aij}* is the technical coefficients matrix (aij = xij/xj); the proportions of each good (*i*) produced in the economy used as a direct input to produce one unit of good *j*. The solution to the model is:

x = (I – A)-1y

As it is well known, the entries of the Leontief matrix (I – A)-1 are the multipliers, i.e., the direct plus indirect amounts of each good used as an input in the system to produce one unit of each good.

Pasinetti (1973: 1986) includes a few further concepts and suggests that each sector can be taken as an open subsystem demanding inputs directly and indirectly in order to produce a homogeneous output destined to satisfy final demand. Such are called “vertically integrated sectors”. De Juan (1996) defines such subsystems as autarkic, i.e., each sector should be able to provide every input it requires to produce its output. Of course that condition is possible only through exchange, because each branch sells produced goods in a value equal to its demands for inputs in order to preserve equilibrium.

Pasinetti (1973) explains that vertically integrated sectors are formally similar to sectors that derive from the IO model, assuming that the economy employs no fixed capital. In such model, intermediate inputs are also circulating capital whose production demands produced goods as inputs in a circular flow model. Columns of the so-called Leontief matrix show the total input requirements in order to produce one unit of each good and final demand determines the size of output. Each column of matrix *(I – A)-1* is therefore a subsystem that produces one homogeneous good. If fixed capital is also consumed in production, matrix *A* should be replaced by an augmented matrix *A+*, the sum of the technical coefficients matrix and the capital consumption array (Pasinetti, 1973).

Within the IO model, the necessary amount of factors to produce one unit of each good in every vertically integrated sector will be given by the following:

’= f’ (I – A)-1

*f'* is the row vector of physical coefficients of non-produced factors. Vector *f’* can be decomposed as: *f’ = l’ + k’ + m’*; *l’* is the row vector of labour coefficients (the amount of workers employed in each sector divided by gross output); *k’* stands for the row vector of capital stock coefficients (capital stock divided by output) and *m’* will stand for the row vector of intermediate imports coefficients. Pasinetti analyses extensively equation

’= l’ (I – A)-1

the total labour content in the vertically integrated sectors for various theoretical reasons, besides the well-known controversy on the measurement of capital (Hartcourt and XXX, 2009). However, according to Leontief (1928 and 1937) all factors are equally necessary to perform production (i.e., if one is lacking production cannot be carried out)[[2]](#footnote-2). Therefore, the following equations are also valid:

’= k’ (I – A)-1

’= m’ (I – A)-1

showing the necessary amounts of capital and intermediate imports to produce one unit of goods in each vertically integrated sector.

Clearly there is an inverse relationship between the total amount of employed factors and their productivity. The latter can be written as (de Juan, 1996):

l’ = (’

k’ = (’

m = (’)-1

the entries of each vector show the productivity of each factor employed directly and indirectly in the production processes of each sector. Differences between the latter measures and the direct productivity measures discussed above can be attributed to the factor employment indirectly in each industry.

Industries that employ larger proportions of factors directly will also use smaller proportions of produced inputs. Their relationships with the rest of the industries will be relatively less complex. If productivity per unit of factor employed is higher when the industry uses relatively more produced inputs, the indirect use of factors through inputs will be lower. Hence, a sector that shows a complex relationship with the rest of the economy will show.

**Results**

Table 1 shows the results of the inverse relationship between the total amount of employed factors and their productivity. In this relationship, the US economy is more productive in the capital stocks, Mexico in job creation and Canada in imports.

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| Table 1The inverse relationship between total amount of employed factors and their productivity |
| Setors | Canada | U.S.A | Mexico |
| k’ | l’ | m | k’ | l’ | m | k’ | l’ | m |
|  Agriculture, hunting, forestry and fishing | 15.42 | 39.08 | 11.56 | 19.06 | 69.71 | 11.20 | 18.58 | 27.58 | 20.96 |
| Mining and quarrying (energy) & (non-energy) | 25.93 | 146.28 | 20.86 | 3.86 | 156.35 | 11.77 | 7.29 | 23.57 | 42.27 |
| Food products, beverages and tobacco | 17.84 | 48.05 | 11.09 | 14.98 | 75.61 | 12.05 | 18.86 | 12.24 | 17.10 |
| Textiles, textile products, leather and footwear | 15.34 | 42.98 | 5.05 | 9.80 | 65.86 | 5.81 | 14.59 | 11.80 | 6.10 |
|  Wood and products of wood and cork | 17.53 | 45.52 | 13.25 | 7.42 | 66.12 | 9.52 | 15.34 | 8.77 | 13.57 |
|  Pulp, paper, paper products, printing and publishing | 9.77 | 52.45 | 13.84 | 4.31 | 91.70 | 15.86 | 10.52 | 63.12 | 10.52 |
|  Coke, refined petroleum products and nuclear fuel | 7.74 | 56.64 | 3.10 | 6.50 | 104.52 | 3.47 | 6.36 | 43.14 | 10.43 |
|  Chemicals excluding pharmaceuticals & Pharmaceuticals | 11.15 | 67.69 | 6.87 | 13.00 | 104.39 | 7.72 | 13.01 | 76.29 | 9.80 |
|  Rubber & plastics products | 13.93 | 60.93 | 6.41 | 13.20 | 84.40 | 6.79 | 13.11 | 14.65 | 5.76 |
|  Other non-metallic mineral products | 14.84 | 68.40 | 11.66 | 14.82 | 94.39 | 14.45 | 17.07 | 58.43 | 16.21 |
|  Iron & steel & Non-ferrous metals | 11.55 | 60.77 | 4.60 | 10.98 | 88.23 | 5.02 | 12.37 | 35.30 | 8.33 |
|  Fabricated metal products, except machinery & equipment | 10.98 | 55.88 | 6.57 | 8.29 | 78.41 | 8.27 | 9.47 | 24.07 | 6.24 |
|  Machinery & equipment, nec & Electrical machinery & apparatus, nec | 4.03 | 61.30 | 6.10 | 1.89 | 83.62 | 7.42 | 3.91 | 59.23 | 4.44 |
|  Office, accounting & computing machinery & Radio, television & communication equipment & Medical, precision & optical instruments & Manufacturing nec; recycling (include Furniture) | 5.19 | 57.96 | 5.07 | 2.00 | 80.09 | 7.38 | 6.18 | 43.58 | 2.99 |
|  Motor vehicles, trailers & semi-trailers & Building & repairing of ships & boats & Aircraft & spacecraft & Railroad equipment & transport equip nec. | 4.99 | 64.84 | 4.72 | 1.94 | 79.71 | 5.04 | 3.37 | 59.97 | 4.84 |
|  Production, collection and distribution of electricity & Manufacture of gas; distribution of gaseous fuels through mains & Steam and hot water supply & Collection, purification and distribution of water | 20.43 | 120.19 | 15.14 | 8.17 | 171.38 | 8.06 | 7.99 | 24.55 | 12.41 |
|  Construction | 1.06 | 52.45 | 10.37 | 1.06 | 69.87 | 13.71 | 1.02 | 83.01 | 16.37 |
|  Wholesale & retail trade; repairs | 9.55 | 42.59 | 29.33 | 9.83 | 72.26 | 35.29 | 11.51 | 24.87 | 30.15 |
|  Hotels & restaurants | 22.42 | 26.91 | 17.38 | 19.43 | 42.63 | 23.97 | 28.93 | 25.44 | 49.53 |
|  Land transport; transport via pipelines | 12.99 | 58.09 | 16.40 | 10.03 | 94.41 | 16.01 | 13.76 | 27.60 | 20.93 |
|  Water transport | 11.57 | 50.08 | 8.14 | 12.49 | 95.92 | 15.45 | 8.67 | 35.33 | 9.48 |
|  Air transport | 14.66 | 48.77 | 6.70 | 9.99 | 86.55 | 8.91 | 10.79 | 44.70 | 6.80 |
|  Supporting and auxiliary transport activities; activities of travel agencies | 15.85 | 44.57 | 18.16 | 44.22 | 22.43 | 65.33 | 18.72 | 22.19 | 33.84 |
|  Post & telecommunications | 22.75 | 24.55 | 27.76 | 11.36 | 106.59 | 25.82 | 24.48 | 38.05 | 21.47 |
|  Finance & insurance & Real estate activities | 11.61 | 56.16 | 44.70 | 10.81 | 203.60 | 48.19 | 44.12 | 15.12 | 81.01 |
|  Renting of machinery & equipment | 19.37 | 71.84 | 24.97 | 16.40 | 110.63 | 29.14 | 54.97 | 40.24 | 74.79 |
|  Computer & related activities | 7.15 | 87.99 | 21.39 | 2.56 | 95.38 | 22.92 | 15.62 | 2.90 | 26.98 |
|  Research & development & Other Business Activities | 19.17 | 157.56 | 27.72 | 14.23 | 63.68 | 42.53 | 25.61 | 25.99 | 35.66 |
|  Public admin. & defence; compulsory social security | 16.23 | 56.84 | 20.54 | 12.60 | 89.20 | 19.51 | 22.59 | 25.06 | 45.42 |
|  Education | 30.34 | 49.42 | 47.35 | 14.12 | 13.91 | 36.69 | 48.84 | 22.24 | 119.25 |
|  Health & social work | 29.40 | 37.32 | 19.21 | 22.18 | 63.91 | 26.39 | 34.52 | 24.87 | 32.27 |
|  Other community, social & personal services & Private households with employed persons & extra-territorial organisations & bodies | 23.20 | 48.32 | 19.01 | 17.19 | 83.49 | 23.64 | 31.12 | 32.14 | 48.72 |
| Promedio | 14.81 | 61.33 | 15.78 | 11.52 | 87.78 | 18.54 | 17.92 | 33.63 | 26.39 |

In Canada, the sector with the highest productivity in the capital stocks is the Construction and after it are Machinery & equipment, nec & Electrical machinery & apparatus, nec; Office, accounting & computing machinery & Radio, television & communication equipment & Medical, precision & optical instruments & Manufacturing nec; recycling (include Furniture); and Motor vehicles, trailers & semi-trailers & Building & repairing of ships & boats & Aircraft & spacecraft & Railroad equipment & transport equip nec. For employment productivity the principal sectors are; Food products, beverages and tobacco; Textiles, textile products, leather and footwear; and Wood and products of wood and cork. Finally the principal sectors for imports productivity are Textiles, textile products, leather and footwear; Iron & steel & Non-ferrous metals; and Motor vehicles, trailers & semi-trailers & Building & repairing of ships & boats & Aircraft & spacecraft & Railroad equipment & transport equip nec.

The Construction in US is the sector whit highest productivity in the capital stocks, however there are more sectors with highest productivity like Mining and quarrying (energy) & (non-energy); Pulp, paper, paper products, printing and publishing; Machinery & equipment, nec & Electrical machinery & apparatus, nec; Office, accounting & computing machinery & Radio, television & communication equipment & Medical, precision & optical instruments & Manufacturing nec; recycling (include Furniture); and Motor vehicles, trailers & semi-trailers & Building & repairing of ships & boats & Aircraft & spacecraft & Railroad equipment & transport equip nec. In the case of productivity employment the principal sectors are Agriculture, hunting, forestry and fishing; Textiles, textile products, leather and footwear; Wood and products of wood and cork; Hotels & restaurants; and Research & development & Other Business Activities. Finally the productivity imports components, the principal sectors are Textiles, textile products, leather and footwear; Coke, refined petroleum products and nuclear fuel; Iron & steel & Non-ferrous metals; and Motor vehicles, trailers & semi-trailers & Building & repairing of ships & boats & Aircraft & spacecraft & Railroad equipment & transport equip nec.

In the case of Mexican economy the highest productivity in the capital stocks are the sector of Construction, Machinery & equipment, nec & Electrical machinery & apparatus, nec; and Motor vehicles, trailers & semi-trailers & Building & repairing of ships & boats & Aircraft & spacecraft & Railroad equipment & transport equip nec. In the case of employment productivity the principal sectors are Food products, beverages and tobacco; Textiles, textile products, leather and footwear; Wood and products of wood and cork; and Computer & related activities. Finally in the case of imports productivity Textiles, textile products, leather and footwear; Rubber & plastics products; Fabricated metal products, except machinery & equipment; Machinery & equipment, nec & Electrical machinery & apparatus, nec; Office, accounting & computing machinery & Radio, television & communication equipment & Medical, precision & optical instruments & Manufacturing nec; recycling (include Furniture); Motor vehicles, trailers & semi-trailers & Building & repairing of ships & boats & Aircraft & spacecraft & Railroad equipment & transport equip nec.; Water transport; and Air transport.

Conclusions

The Motor vehicles, trailers & semi-trailers & Building & repairing of ships & boats & Aircraft & spacecraft & Railroad equipment & transport equip nec. sector is the most productive in the structure of North America. The US economy is highly productive sectors ranging from primary, secondary and service sectors, in the case of its trading partners, Canada has increased productivity in secotres such as Food products, beverages and tobacco; Textiles, textile products, leather and footwear; and Wood and products of wood and cork. However Mexican economy has their principal productivity sectors in the manufacture industry, in branch like Machinery & equipment, nec & Electrical machinery & apparatus, nec; Office, accounting & computing machinery & Radio, television & communication equipment & Medical, precision & optical instruments & Manufacturing nec; recycling (include Furniture); Motor vehicles, trailers & semi-trailers & Building & repairing of ships & boats & Aircraft & spacecraft & Railroad equipment & transport equip nec.

These results show that the Mexican economy has had a high profit by the free trade agreement with the neighbors to the north that is translated into high productivity in high-tech sectors employing

1. Professors of Facultad de Economía UNAM, aroche@servidor.unam.mx y antoniomrqz@gmail.com [↑](#footnote-ref-1)
2. Leontief developed a production model, but avoided discussing the theory of value (Aroche, 2015) [↑](#footnote-ref-2)