WHAT IS PRODUCTIVITY?

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Centre for Productivity and Prosperity

HEC MONTRÉAL

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Abstract

Frequently discussed in economic news, the concept of productivity is complex and its implications on the economy and on the population are still not very well understood. Often not well perceived, we forget that an improvement of the productivity is not only an end, it is also a mean available to society to improve its economic prosperity and to give a better quality of life to its population. The principal goal of this document is to popularize the economic concepts surrounding productivity and to clarify the important role it plays in the economic development of a country. Accordingly, the document focuses on answering three key questions:

- What is productivity?
- What is the role of productivity?
- What are the determinants of productivity?

The section *Definition and Measures of Productivity* defines productivity by introducing several measures of productivity. The section *Role of Productivity* provides evidence on the link between productivity and the standard of living of an individual or a country as a whole.[i] Finally, the section *Determinants of Productivity* discusses the main factors that influence productivity. Besides addressing the usual physical capital and technology investments, a particular attention is given to specialization and trade and its relation to productivity

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Definition and Measures of Productivity

Usually productivity refers to the productive ability of an input or a group of inputs in a given period of time. A measure of productivity thus provides information on the efficiency by which resources are transformed in output. Productivity is measured by taking the ratio between production and one or more factors used in the production process.

Although there are a variety of different productivity measures, we first focus our attention on labour productivity. This measure is of a particular interest being the measure of productivity most frequently used, and this, mainly because of its simplicity of interpretation.

Labour Productivity

Labour productivity provides information on the efficiency by which workers transform their work effort into production. It is calculated by taking the ratio between the total output and the amount of work needed to produce it. Below is a simple example to help us better understand this first measure of productivity.

Quebec's forest industry gives us the ideal frame to calculate and conceptualize productivity and to show how it operates in the real world. We first analyze the quantity of wood cut by lumberjacks within a year. Here, the output is calculated in terms of volume of cut trees (in m^3) and the input (resources used) is measured by the number of lumberjacks employed during the given year.

In 1970, 14,900 lumberjacks were employed in the Quebec forest industry. In total, they harvested 23.7 million cubic meters (m^3) of wood.[ii] With these two pieces of information in hand, we are now able to compute our first measure of productivity, i.e. the average yearly production of a lumberjack. In 1970, each lumberjack cut 1590.6 m^3 of wood a year:

$$\frac{23.7\ million\ m^3\ of\ wood}{14{,}900\ lumberjacks} = 1590.6\ m^3/year.$$

In other words, in 1970, a lumberjack's productivity was equal to 1590.6 m^3 / year.

While the above measure provides some information about the productive ability of an average lumberjack, other more specific measures exist, such as the hourly productive ability of a lumberjack. This measure represents the production generated by one working hour; it can be used as a tool when fixing hourly wages. Indeed, because the hourly production of a lumberjack has a certain market value, it partly determines the work value of a lumberjack and thus the wages he should earn.

Suppose that in 1970, each lumberjack worked 8 hours a day during 200 days. Again, the annual production is 23.7 million m^3 of wood and the average total number of hours worked by a lumberjack is 200*8 = 1,600 hours per year. Thus, in 1970, each lumberjack cut on average 0.99 m^3 of wood every hour.

$$\frac{23.7\ million\ m^3\ of\ wood}{14{,}900\ lumberjacks * 200\ days * 8\ hours} = 0.99\ m^3/hour$$

Knowing that one cubic meter of wood is the equivalent of approximately a cord of wood and supposing that the market price is $50 per cord, one can affirm that the work of a lumberjack is worth a maximum of $50 an hour.

Evolution of Labour Productivity

So far, we have looked at the productivity level at a specific moment in time. However, over time productivity generally tends to improve. Its evolution is an indicator of the improvement in the capacity to produce considering the factors of production at hand. In other words, when, for example, labour productivity increases, each hour worked generates a greater quantity of production than before.

These gains can come from various sources, particularly from an improvement in the abilities of the workers or simply from a progress in the techniques of production. The division of labour and the Taylorism are striking examples of a change in the production process which allowed significant productivity gains.

As we will further see it, productivity gains are the fundamental driving forces behind the evolution of the standard of living of an economy. The situation in the forest industry precisely shows the consequences of the productivity gains in a sector and the spillover effect on the rest of the economy.

In the forest industry, the productive ability of a lumberjack has evolved over the years due, in part, to improvements in skills, nutrition and living conditions in lumberjacks camps, health, etc. In 1987, 34.3 million m^3 of wood were cut by only 12,000 lumberjacks. Assuming that each lumberjack still worked 8 hours a day during 200 days in 1987, the labour productivity increased by 81% from 0.99 m^3 to 1.79 m^3:

$$\frac{34.3\ million\ m^3\ of\ wood}{12{,}000\ lumberjacks * 200\ days * 8\ hours} = 1.79\ m^3/hour$$

It was thus possible to cut a much more important quantity of wood than in 1970 with a reduced number of lumberjacks, allowing reallocation of productive labour towards various other production activities in the economy.

One can see from this example that productivity and production are closely related to each other, the raise of productivity allowing an increase in the production of wood. However, observing an increase in productivity is not enough to infer the direction of a change in production. Indeed, suppose that lumberjacks had been able to cut only 20 million m^3 of trees in 1987, while everything else remained the same. Then, production would have decreased from 23.7 to 20 million, but productivity would still have increased from 0.99 m^3 to 1.04 m^3. In this example, it is the decrease in the number of lumberjacks that would have made it possible to observe at the same time an increase in productivity and a significant decrease in production.

Interpretation Warning

Although labour productivity seems to be a direct measure of the productive ability of the workers, it must be interpreted with some reservations. Because it considers only one factor, labour productivity alone makes it impossible to measure the effect of the variations in the use of other production factors. A productivity gain can be misinterpreted, being wrongly associated to an efficiency increase whereas the productivity gain takes origin in a labor to capital substitution (in particular by the addition of new machinery). In the forest industry example, are improvements in skills, nutrition, and health conditions the sole reasons explaining the increase in labour productivity? Over time machinery and technology were introduced in the wood cutting industry and have been found to be also responsible for the increase in the productive ability of lumberjacks. More precisely, in the forest industry between 1981 and 1987, the proportion of mechanically harvested wood increased from 32% to 59%, leading the way to a significant rise in labour productivity (Mercure, 2006). The use of new technologies had a direct effect whereas lumberjacks could cut more trees in the same lapse of time. Thus, caution must be used when interpreting labour productivity growth since it can be highly influenced by an accumulation of other production factors such as capital.

Other Measures of Productivity

In addition to labour productivity, other productivity measures can be calculated such as capital productivity.[iii] The same interpretation given to labour productivity can be applied to other single-factor productivity measures. Therefore, capital productivity indicates how efficiently we make use of machinery and thus the productive capacity of the capital on hand.

Let us consider the two productivity measures presented up to this point in the context of the Canadian fishing industry in the Atlantic Ocean.[iv] Table 1 shows that a fisherman can harvest on average 20.55 tons of fish per year. As for capital productivity, an average fishing boat will bring in 44.78 tons of fish per year. From the standpoint of growth, labour productivity decreased from 22.52 to 20.55 tons of fish per fisherman between 1983 and 2002 whereas capital productivity increased from 40.92 to 44.78 tons per fishing boat. The origin of this productivity growth is difficult to identify without a more disaggregated analysis.

1 _ Capital and Labour Productivity
Atlantic Ocean, 1983-2002*

	Capital Productivity Tons of fish/Fishing boat	Labour Productivity Tons of fish/Fisherman
1983	40.92	22.51
1984	35.43	18.44
1985	42.22	23.50
1986	43.52	20.82
1987	43.01	19.97
1988	45.16	20.86
1989	43.40	20.36
1990	45.40	21.60
1991	43.02	20.30
1992	37.17	16.64
1993	33.24	14.32
1994	28.59	12.30
1995	26.04	11.23
1996	29.26	13.62
1997	32.31	16.32
1998	34.88	17.51
1999	39.62	18.93
2000	41.98	20.78
2001	43.22	20.91
2002	44.77	20.55

*Authors' calculations

Breaking down fish species makes it possible to identify the growth's origin (see Table 2). It seems that the use of physical capital in shrimp, scallop and lobster fishing improved through the years resulting in an increase of aggregated productivity in spite of a significant decrease in groundfish and capelin productivity levels. The same reasoning applies to the economy as a whole. Some sectors present a negative productivity growth, others a positive, but in general productivity levels follow an ascending trajectory.

Table 2 shows some stunning facts.[v] How can a shrimp boat be nearly 50 times more productive than a lobster boat? This important productivity gap can be partly attributed to significant market price differences for each specie reflecting, for example, fish harvesting difficulties for a specific specie and thus its scarcity. Indeed, if the market price for a ton of shrimps is lower than for a ton of lobsters, for example, then productivity for harvesting lobsters, measured in dollars, could exceed the shrimps'. Considering these issues, converting production measures into a common denominator, monetary value for instance, might be useful.

2 _PRODUCTIVITY BY SPECIES, TONS OF FISH PER PERMIT *

	Productivity by Species							
	Groundfish	Herring	Mackerel	Capelin	Scallop	Lobster	Shrimp	Crab
1983	48.52	24.47	4.62	34.37	26.92	2.65	117.35	144.04
1984	44.14	18.44	3.84	44.32	17.96	2.58	93.82	93.02
1985	47.33	27.22	6.11	34.93	22.27	2.90	92.54	78.17
1986	49.80	24.16	5.64	33.10	26.57	3.31	99.96	60.81
1987	47.88	24.99	5.37	12.36	37.86	3.44	157.19	36.60
1988	45.14	28.87	4.68	31.51	38.00	3.51	233.21	29.00
1989	42.06	24.27	3.91	29.11	43.02	3.81	265.28	20.84
1990	39.85	28.18	4.05	41.05	38.49	4.14	230.02	22.86
1991	36.42	23.79	4.69	15.83	36.78	4.23	252.34	29.57
1992	27.06	24.35	4.88	10.14	40.98	3.67	236.82	30.41
1993	22.68	22.88	4.59	16.34	37.30	3.62	263.45	40.23
1994	10.92	23.05	2.98	0.78	36.38	3.72	278.17	52.00
1995	7.80	21.74	2.47	0.10	27.58	3.74	328.80	56.39
1996	9.11	21.50	2.70	11.72	24.99	3.66	344.23	52.10
1997	9.98	21.30	2.58	7.92	27.45	3.69	480.69	56.98
1998	11.20	21.62	2.27	14.33	26.27	3.78	696.32	58.28
1999	13.48	24.87	2.21	10.22	24.98	4.40	209.54	69.86
2000	14.01	25.45	2.24	9.69	37.49	4.50	239.64	60.72
2001	15.18	25.93	3.15	9.68	40.20	5.32	219.88	64.11
2002	13.88	25.10	4.42	6.68	42.72	5.01	232.19	67.30

*** Authors calculations**

Monetary Value of Productivity

In fact, while productivity can be calculated in terms of units of production in the analysis of specific activities, it is generally calculated in terms of dollars as soon as one wants to aggregate production activities or sectors. That is, productivity in monetary terms aims at measuring the value of a combination of production generated by the resources used.

There are two fundamental reasons explaining the use of monetary value in productivity measures. First, the nature of monetary unit makes it possible to compare the incomparable. For the same reasons that it is used in commercial transactions, monetary conversion in productivity measurements allows the comparison of different productions in quality and nature. Second, monetary conversion not only allows the comparison but also the aggregation of productivity measures at an industrial level to eventually calculate nation-wide productivity measures.

Monetary conversion in productivity measurements allows the comparison of different productions in quality and nature.

Measuring Productivity in Monetary Terms

First, take the example of Bombardier, a multinational corporation. Because Bombardier's output is trains and planes, obtaining a measure of labour productivity is impossible unless the production is converted into a common denominator, as in Table 3. Converting the production of planes and trains into a monetary value makes it is now possible to calculate the average productivity of the company as a whole. In 2008, Bombardier's labour productivity was $21,154/worker in 2008.

Financial Statistics for Bombardier Aerospace and Bombardier Transportation, 2008

			BOMBARDIER
Production (in units)	349 planes	N/A	N/A
Value added**	$896 M	$515 M	$1,411 M
Number of employees	32,500	34,200	66,700
Labour productivity (Value added/nomber of employees)	$27,569.23 worker	$15,058.48 worker	$21,154.42 worker

** Value added represents the profit before taxes and interest.

Second, in the example of Hydro-Quebec and Bombardier Aerospace, their respective production measures are kilowatt-hours and planes. These two measures cannot be compared unless converted into dollars.

Financial Statistics for Bombardier Aerospace, 2008

	BOMBARDIER	Hydro Québec
Production (in units)	349 planes	162,1 TWh
Value added**	$896 M	$5 394 M
Number of employees	32,500	23,069
Labour productivity (Value added/number of employees)	$27,569.23 worker	$233,820.28 worker

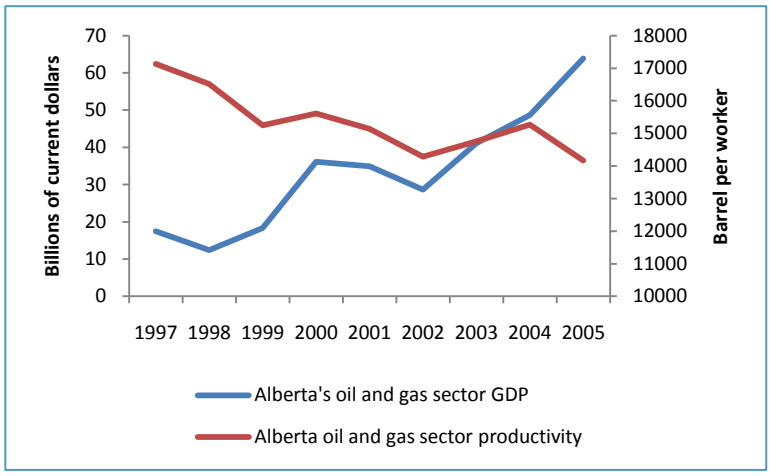
** Value added represents the profit before taxes and interest.

What Productivity is Not

Calculating productivity in monetary terms has several advantages but also a certain number of defects. It is thus necessary to clarify the interpretation of productivity. Although a company's productivity gains lead to an efficiency growth and thus a greater competitiveness, one too often mistakes productivity with profitability. A company's or a sector's high level of productivity is not necessarily a synonym for profitability. More precisely, an increase in profits for a company or an industry depends on many other determinants such as the price of goods, the level of competition, the level of the demand, etc.

Take the oil industry in Alberta. Oil prices rose drastically in the past years (market price for a barrel of crude oil rose by close to 200% between 1997 and 2005 – spot West Texas Intermediate). One can imagine that the profits of oil companies rose accordingly. In fact, during the same period, Alberta's oil and gas sector's GDP rose from 17.4 billion in 1997 to 63.9 billion in 2005, a rise of 267%. However, when measured in terms of quantity, the industry's productivity actually dropped by 17.3 % from 17,129.64 to 14,162.25 barrels per worker. Therefore, the increased profits were not due to an increase of the workers' productive ability, but rather to an increase in demand and a higher energy price.

1 _ GDP AND LABOUR PRODUCTIVITY OF ALBERTA'S OIL AND GAS INDUSTRY, 1997-2005*



*** Data on the oil and gas sector are extracted from Statistics Canada: GDP (CANSIM – v3826099), number of worker (CANSIM – v1716836), production of oil and gas (CANSIM – v18050). Productivity measures are authors' calculations.**

Role of Productivity

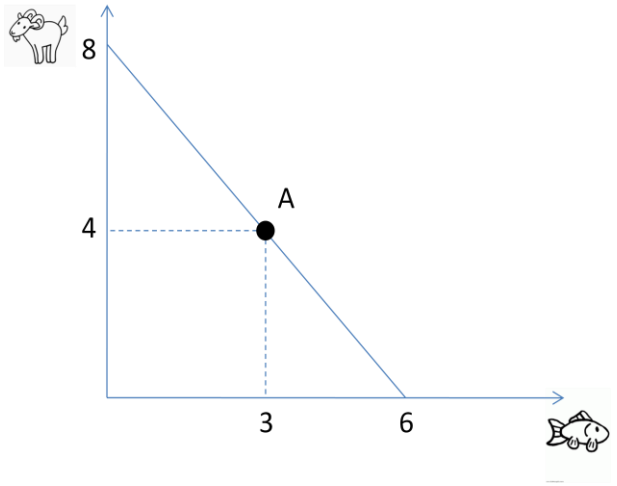
In this section we discuss of the role of productivity on the standard of living.

Robinson's Island

To better understand the links between productivity and standard of living, we take a look at the simple economy famously known as the Robinson Crusoe's island economy. This example is merely used to provide a first understanding of the positive relation between the productivity of an individual and his standard of living. The economic notions learned in this example are applicable to real and more complex economies such as in Quebec and in Canada.

Suppose that Robinson is shipwrecked on a remote tropical island where the only resource or input is the amount of time that he devotes to productive activities on a given day. More precisely, suppose that he can work 12 hours per day, that he allocates his time between the only two possible productive activities on the island: fishing and hunting goats. Robinson is endowed with some technology, i.e. the rule by which Robinson transforms time into goats and fish. It takes Robinson 1.5 hour to catch a goat and 2 hours to catch a fish. Here, for simplicity purposes, the technology is linear. In other words, labour is transformed into fish and goats at constant rates. Finally, the price for either good is normalized to one dollar.

2_PRODUCTION POSSIBILITIES FRONTIER FOR ROBINSON



As per this information, everyday, Robinson can catch either 12/1.5 = 8 goats or 12/2 = 6 fish, or a linear combination of goats and fish such as the total amount of work reaches 12 hours, as depicted by the Production Possibilities Frontier (PPF) in Figure 2. Using the same method as in the previous section, labour productivity is the ratio between the production and the resources used. For example, if Robinson chooses to only hunt goats, his productivity will be 8 goats, or, 8 dollars. If he chooses to produce 4 goats and 3 fish (point A), his productivity will then be 4*1 + 3*1 = 7 dollars per working day. In autarky, his production possibilities are equal to his consumption possibilities. Thus, if Robinson produces at point A, he enjoys a consumption bundle worth 7 dollars.

In our simple economy, it appears clearly that the productivity of an individual is positively linked to his standard of living since his productive capacity is equal to his consumption capacity, where the consumption capacity is a good proxy for the standard of living. If Robinson is more efficient at hunting and fishing,his PPF will shift to the right implying that both his productivity and his standard of living will increase. In addition, as Robinson betters his skills, he might decide to reduce his productive activities in favor of increasing his leisure. His quality of life will then improve since an increase in productivity will also increase the number of goods available for consumption from two to three, where leisure is also considered a good. The same phenomenon applies to a national level. In theory, the more an economy or a country is able to produce using its available resources, the more its standard of living will rise.

Productivity and Standard of Living

Considering that the example of Robinson's island is without a doubt very simplistic, questioning the conclusions stated above is fairly reasonable. Empirical analysis, however, allows reconciliation of the theory with reality. The first interesting empirical link that we examine is between salaries and productivity. The higher the productivity of a worker is, the higher the value of his work, thus of is salary, will be, which will allow them to enjoy a higher level of consumption, that is, a higher standard of living. Table 3 shows that productivity growth is strongly correlated to the growth of total actual remuneration. In Canada, between 1997 and 2007, the productivity growth was 17.91%, while the total remuneration growth was 17.98%. Similarly, in Quebec, the productivity and remuneration growths were 13.30% and 13.79%, respectively. These figures clearly show that remuneration is positively correlated to productivity growth.

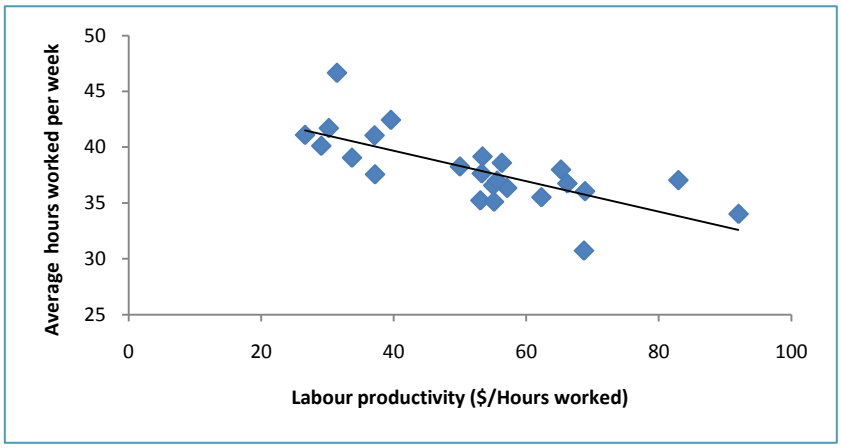
3 _ GROWTH OF TOTAL ACTUAL REMUNERATION BY HOURS WORKED AND LABOUR PRODUCTIVITY GROWTH, CANADA AND THE PROVINCES, 1997-2007*

	Total actual remuneration / Hours worked	Labour productivity (GDP $2002 / Hours worked)
Canada	15.76 %	15.66 %
Newfoundland and Labrador	27.38 %	42.32 %
Prince Edward Island	13.05 %	16.64 %
Nova Scotia	15.72 %	15.14 %
New Brunswick	12.90 %	19.22 %
Quebec	13.79 %	13.30 %
Ontario	10.63 %	15.43 %
Manitoba	18.49 %	18.33 %
Saskatchewan	26.18 %	19.44 %
Alberta	30.32 %	8.79 %
British Columbia	13.50 %	12.74 %
Average	17.98 %	17.91 %

* Data on total actual remuneration are extracted from Statistics Canada CANSIM (Total remuneration per hour – CANSIM 3830009 and CPI – 3260021. Productivity growths are authors' calculations from data provided by Statistics Canada.

On top of increasing remuneration, we observe that an increase in productivity allows workers to work less and to spend more time doing leisure activities, which also raises their quality of life. Recall that Robinson could enjoy the consumption of a third good, leisure, if he was efficient enough conducting the two productive activities essential to his survival. See Figure 3 for strong evidence on the relation between productivity and leisure across countries. The figure actually shows a negative link between productivity and the number of hours worked for OCDE countries, thus a positive link between the level of productivity and time available to do leisure activities.

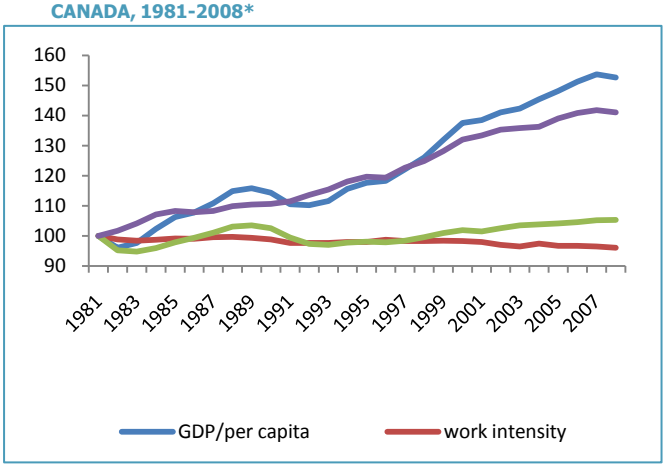
3_ RELATION BETWEEN LABOUR PRODUCTIVITY AND AVERAGE HOURS WORKED BY WEEK, OCDE COUNTRIES, 2008*



* Data on labour productivity are extracted from Productivity and Prosperity in Quebec, 1981-2008 Overview, Center for Productivity and Prosperity, HEC Montréal, 2009. Average hours worked by week extracted from OECD Stat.

At the aggregate level, the standard of living of a country depends on the productivity of all its workers. Figure 4 shows evidence that GDP per capita (a proxy for standard of living) is strongly correlated with labour productivity. Of all potential factors explaining the growth of GDP per capita during the past 30 years, none of them have registered a growth comparable to the growth of labour productivity.[vi]

4_ DECOMPOSITION OF LABOUR PRODUCTIVITY GROWTH, CANADA, 1981-2008*



* Authors' calculations from data provided by Statistics Canada.

Determinants of Productivity

In the previous section, we have shown how the productivity of an individual and a country as a whole is positively related to the standard of living. This section treats of two main determinants of productivity, and of standard of living. To facilitate matters, we keep on working with the example of Robinon's Island.

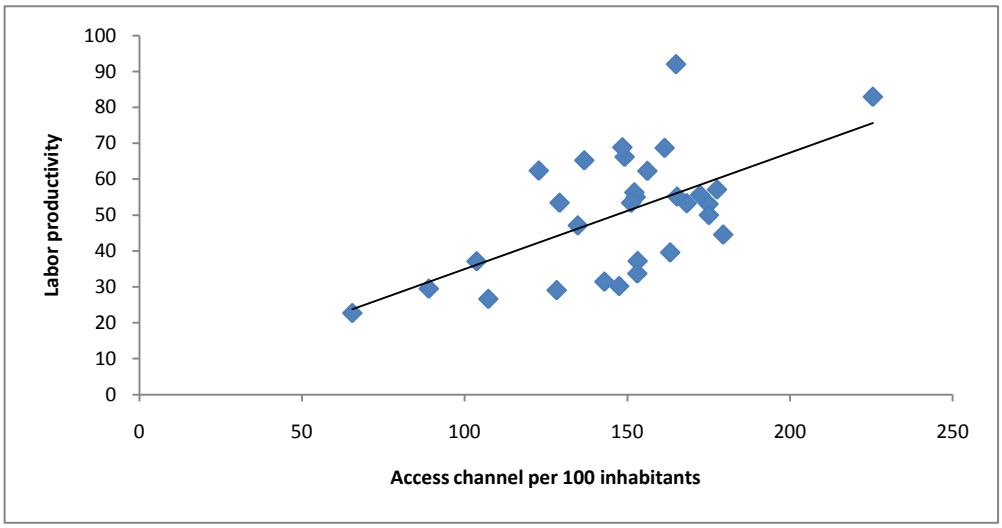
Physical Capital and Technology

If Robinson had more physical capital, would he be more productive? Suppose that Robinson has the ability to weave a fishing net. It takes him 3 hours to do this, but once the fishing net is set up, it will only take one hour to catch a fish instead of two. Also, each day he can choose to use or not his fishing net. However, whatever he decides to do, he must devote 3 hours of his time to the maintenance of his fishing net.[vii] Therefore, after spending 3 hours weaving the net, Robinson has 12 – 3 = 9 hours left for hunting or fishing. Robinson may catch either 9/1.5 = 6 goats or 9/1 = 9 fish, or a combination of goats and fish such that the total amount of work reaches 9 hours. Two conclusions on physical capital and technology investments can be drawn from this example. First, the accumulation of physical capital comes at a cost. Here, the cost of use of the fishing net is calculated in terms of available working hours. Second, using the fishing net, Robinson's productive ability is increased from 6 to 9 fish, but decreased from 8 to 6 goats. Consequently, there is also a cost in terms of productivity from one sector to another.

Why would Robinson weave a net? This depends ultimately on his preferences. If he prefers fish, then he will invest in the fishing net, which will increase his productivity if he allocates most of his time to fishing. However, productivity could decrease in spite of capital accumulation. That would happen if Robinson weaved the net, but decided to allocate most of his time to hunting goats. In a simple economy such as this one, this would be unlikely because Robinson is alone. However, in a more complex economy, with several agents, institutions, and government agencies, coordination problems may arise.

However, in most cases, any improvement in physical capital or technology increases the productivity, and the standard of living. This is confirmed with Figure 5, where labour productivity and technology are positively related across countries. [viii]

5_ Labour productivity and technology, Access channel per 100 inhabitants*

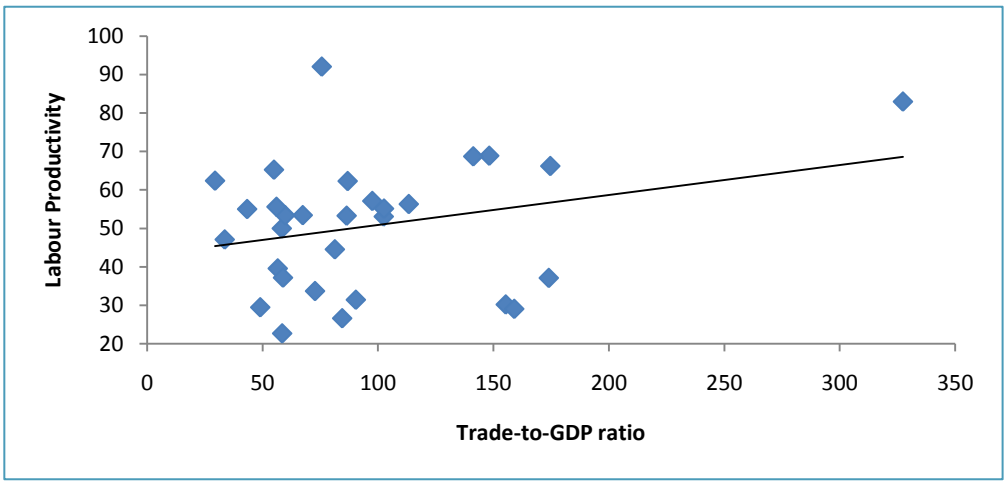


* Data on labour productivity are extracted from Productivity and Prosperity in Quebec, 1981-2008, Overview, Centre for Productivity and Prosperity, HEC Montréal, 2009. Data on access channel per 100 inhabitants are extracted from OECD Stat. Access channel data are for the year 2005 which are the latest available data

Specialization and Trade

The productivity of individuals and ultimately of a country strongly depends on their level of specialization and trade. In a nutshell, specialization and trade allow individuals to be on average more productive and to reach a higher level of consumption they would have without specialization and trade. Figure 6 provides some evidence of a positive relation between labour productivity and trade openness for the OECD countries.

6_ LINK BETWEEN LABOUR PRODUCTIVITY AND OPENNESS TO TRADE*



* Trade-to-GDP is defined as the sum of import plus export divided by national GDP. Data on trade-to-GDP are extracted from OECD Stats while data on labour productivity are extracted from Productivity and prosperity in Quebec, 1981-2008 Overview, Centre for productivity and prosperity, HEC Montréal, 2009.

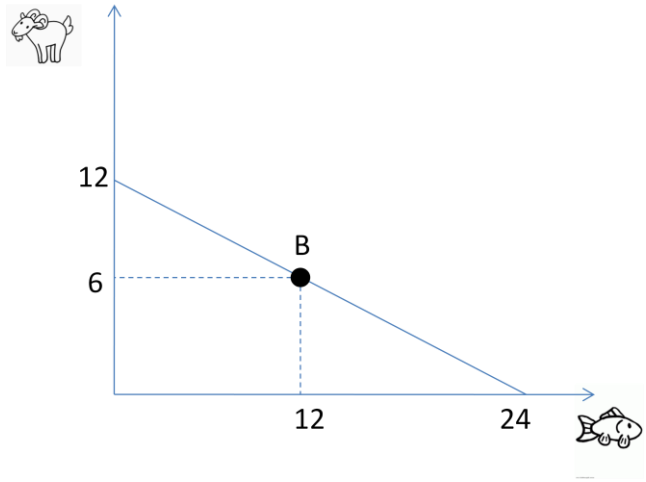
In our simple economy treated in the previous section, Robinson needs 1.5 hour to catch a goat and 2 hours to catch a fish. Recall that under autarky his production and consumption possibilities are the same (Figure 3). If he produces and consumes at point A, where he catches 4 goats and 3 fish, then Robinson's productivity is 4*1 + 3*1 = 7 dollars per working day.

The productivity of individuals and ultimately of a country strongly depends on their level of specialization and trade. In a nutshell, specialization and trade allows individuals to be on average more productive and to reach a higher level of consumption they would have without specialization and exchange. Figure 6 provides some evidence of a positive relation between labour productivity and trade openness.

Suppose now that Robinson is joined by Friday. Friday has also 12 hours per day available for either hunting or fishing. It takes Friday 1 hour to catch a goat and half an hour to catch a fish. We can also draw Friday's production and consumption possibilities frontier in Figure 7. Suppose Friday decides to produce at point B, where he produces 6 goats and 12 fish, his productivity is then 6*1 + 12*1 = 18 dollars per working day.

If Robinson and Friday do not engage in trade (exchange), and produce and consume at point A and B then the average productivity is (7+18)/2 = 12.5 dollars per working day. Although Friday is just a more skilled individual, should he nonetheless trade with Robinson? Would trade (or exchange) lead to a higher productivity for both Friday and Robinson? The answer is yes but only if Friday and Robinson specialize according to their comparative advantage. Then the question is: what is the best distribution of the productive activities between Friday and Robinson?

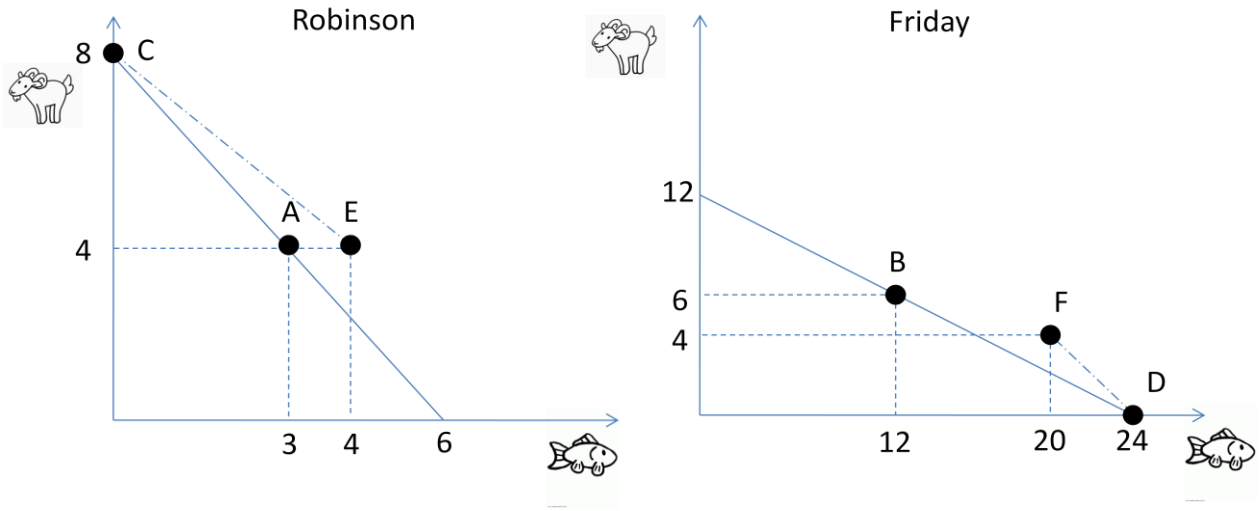
7 _ Production Possibilities Frontier for Friday



In our example, Friday's opportunity cost[ix] for producing one fish is 1/2 of a goat while Robinson's opportunity cost for producing one fish is 4/3 of a goat. Because his opportunity cost for producing fish is lowest, we say that Friday has a comparative advantage in the production of fish. Therefore, Friday should specialize in fishing. Next, Friday's opportunity cost for producing one goat is 2 fish while Robinson's opportunity cost of producing one goat is 3/4 of a fish. Robinson has a comparative advantage in the production of goats and should specialize in hunting goats.[x]

Having each individual specialize according to their comparative advantage allocates resources efficiently from a collective standpoint since they produce the maximum quantity possible with the resources at hand. Therefore, when Friday produces fish exclusively (point D in Figure 8), his productivity is 24 dollars and when Robinson produces goats exclusively (point C), his productivity is 8 dollars. However, without any exchange, none of the benefits from specialization can materialize and lead to higher consumption and standard of living.[xi] Given that the price of a goat or a fish is one dollar, the terms of trade are one fish for one goat. In these circumstances, Friday could exchange 4 fish for 4 goats from Robinson and achieve a point beyond their PPF, i.e., Robinson consumes 4 goats and 4 fish (point E), while Friday consumes 4 goats and 20 fish (point F). Both points E and F are achievable only through specialization and trade, as they are beyond their production possibilities frontier. Whether Robinson and Friday trade with each other will ultimately depend on their preferences, but specialization and trade lead to higher potential consumption for both individuals.

8 _ Production Possibilities Frontier After Specialization and Trade



We have learned two important things from this example. First, a more integrated economy yields a higher average productivity. Second, although specialization might reduce the productivity of *some* individuals, by raising the average productivity, it allows all individuals to consume beyond their possibilities if isolated. Specialization and trade thus provides more freedom in terms of consumption, and opens the possibility to a higher standard of living.[xii]

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[i] Here, standard of living refers to a level of material comfort in terms of goods and services available to a person or a group of person. A country's standard of living is measured by the GDP per capita.

[ii] Data on the lumber industry are extracted from Mercure (2006).

[iii] For more information on other productivity measures please refer to OECD Manual - Measuring Productivity: Measurement of Aggregate and Industry-Level Productivity Growth : www.oecd.org/dataoecd/59/29/2352458.pdf.

[iv] Data on the fishing industry are extracted from Fisheries and Oceans Canada's online statistical database at : http://www.dfo-mpo.gc.ca/communic/statistics/commercial/index_e.htm.

[v] The number of species was estimated due to the absence of data on fishing boats.

[vi] For a complete explanation of the decomposition of GDP growth please see Productivity and Prosperity in Quebec, 1981-2008 Overview, Center for Productivity and Prosperity, HEC Montréal, 2009.

[vii] In fact, if Robinson wishes to keep his fishing net in good enough condition he must constantly maintain it otherwise his capital will depreciate and will not be usable. Here, daily maintenance of the fishing net corresponds to the cost incurred to avoid depreciation of the capital. One can imagine a similar situation with a company's machinery and material.

[viii] The OCDE defines access channels as the total communication access paths measured as the sum of analogue lines, ISDN lines, DSL, cable modem and mobile subscribers.

ix The opportunity cost of a good is the value of the best alternative that must be forgone. Here, by producing one fish, Robinson needs 1 hour, which could have been used to catch half a goat.

x As long as Robinson and Friday are different in their technology, each one will have a comparative advantage, and, thus, specialization in different sectors will be possible.

[xi] There always exists terms of trade (prices) that yield to voluntary trade that are mutually beneficial.

[xii] While we have chosen specific numbers, there always exist prices of the final goods for which specialization according to comparative advantage and trade would lead to consumption points that are beyond the production possibilities frontier for each individual, unless all individuals are identical in their abilities to produce.