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IDENTIFYING SOUTH AFRICA'S WOOD EXPORTS POTENTIAL USING A GRAVITY MODEL

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Abstract **– South Africa identified the wood products as a priority sector that needs to be developed as it can contribute towards achieving higher levels of economic growth and employment generation. The aim of this paper is to investigate the determinants of South Africa's exports of wood and articles of wood using a gravity model approach. It further investigates whether there is unexploited trade potential between South Africa and its trading partners within this sector. A gravity model was estimated using panel data econometric methodology. The results are in line with the theoretical predictions of the gravity model. The model was simulated to determine the within sample trade potential. The results indicated that there is unexploited trade potential among some South Africa's trading partners. This potential should be exploited in order to stimulate growth, reduce unemployment and alleviate poverty.**

Keywords-component; wood; export potential; panel data; gravity model; South Africa

I. INTRODUCTION

South Africa adopted an export led growth strategy, known as the Growth Employment and Redistribution (GEAR) strategy in 1996 [13]. Various measures were introduced under this strategy in 1996 in order to promote exports. In 2005, under the Accelerated Shared Growth Initiatives – South Africa (ASGISA) the South African government identified priority sectors that need to be developed and promoted in order to accelerate growth and halve poverty by 2014. Among these, the wood sector was identified as a priority sector that needs to be developed for this purpose [17].

Although the wood sector accounted for only 1.3 percent of total exports and 0.2 percent of GDP for the period 1997 to 2004, its development and promotion may contribute towards achieving the objective of halving poverty and reducing unemployment by means of high levels of economic participation and income generation. Given its expected significance and role in the South African economy, it is important to determine its trade potential between South Africa and its trading partners. A useful tool in determining the trade or export potential of a country is the gravity model. The model has its foundations in physical sciences and had proven to be very important in the analysis of bilateral trade flows. Reference [22] and [16] pioneered the idea of explaining trade flows in analogy to Newton's law of gravity by the attraction of two countries' masses, weakened by distance between them and enforced by preferential trade agreements they belong to. The masses of countries are measured by GDP or population and distance between countries measures transport costs. As in physical sciences, the bigger and the closer the units are to each other, the stronger the attraction. The comparison with gravity derives from GDP being a proxy for economic mass and distance as a proxy for resistance.

The gravity model is used to analyse the relationship between volume and direction of international trade and the formation of regional trade agreements where members are in different stages of development. The basic gravity model is augmented with a number of variables to test whether they are relevant in explaining trade between countries [12] These variables include GDP, distance, infrastructure, differences in per capita income and exchange rates.

In light of the above, the objective of this paper is to analyse the factors determining exports of wood and articles of wood, wood charcoal (H44) using a gravity model approach. The paper then investigates whether there is any unexploited trade potential between South Africa and its trading partners within this sector. The rest of the paper is organised as follows. Section II discusses the gravity model. Section III discusses the estimation methodology, while Section IV presents univariate characteristics of the data. The estimation results for the gravity model are presented in Section V while Section VI discusses potential trade. The conclusion is provided in Section VII.

II. THE GRAVITY MODEL

Reference [22] and [16] were the first to apply the gravity model to international trade in the early 1960s. The model has been used in the latter half of the nineteenth century to explain migration and other social flows in terms of gravitational forces of human interaction. As in physical science, the bigger and the closer the units are to each other, the stronger the attraction. The analogy with gravity results from GDP being a proxy for economic mass and distance as a proxy for resistance. Although the gravity model performed very well in analysing trade flows in the 1960s, its strong theoretical foundations were not produced until the end of the 1970s. This led to many studies to modify the original Newtonian gravity equation. The works of [17] and [2;3] made it clear that the gravity model is a good representation irrespective of the structure of product markets. Reference [2;3] included the population size, while [15] included a measure of the price variable.

In an attempt to answer criticisms that the theoretical foundation of the gravity model was weak, [15] derived the gravity equation from the linear expenditure system. Their analysis assumed a weakly separable utility function from which a linear expenditure function could be derived.

The basic gravity equation explains the size of exports from country i to country j by three factors. The first indicates the total potential supply of the exporting country (i), and the second one indicates the potential demand of the importing country (j), and the third includes factors which represents the resistance to trade flow between countries. In its basic form, exports from country i to country j are determined by their economic sizes (GDP), population, geographical distances and a set of dummies which incorporate some kind of institutional characteristics common to specific flows. The gravity model is generally specified as [12; 10; 4].

$$\ln X_{ij} = \beta_0 + \beta_1 \ln Y_i + \beta_2 \ln Y_j + \beta_3 \ln POP_i + \beta_4 \ln POP_j + \beta_5 \ln DIS_{ij} + \beta_6 \ln A_{ij} + u_{ij} \quad (1)$$

where X_{ij} is exports of goods from country i to country j, Y_i and Y_j are the GDP of the exporter and importer, POP_i and POP_j are the populations of the exporter and importer, $DIST_{ij}$ is the distance in kilometres between the two countries, A_{ij} represents any factor that influence trade between the countries, and u_{ij} is the error term.

A high level of GDP indicates a high level of production in the exporting country and can be interpreted as a proxy for the range of product varieties available, which increases the availability of exports. It represents potential supply of exports. The importer's GDP represents potential demand for imports. A high level of GDP or income in the importing country suggests high imports. The coefficients β_1 and β_2 are expected to have positive signs. The population variables can influence export in two ways. A large population indicates a large domestic market and higher degree of self-sufficiency and less need to trade [14]. Large populations also encourage division of labour and this means that there will be economies of scale in production, and opportunities to trade with a variety of goods. For the exporting country, a large population can increase or decrease trade depending on whether the country exports more when it is large or whether the large country export less than the smaller one. For the importing country a large population can also increase or decrease trade for the same reasons. Thus, the effects of population for both the exporting and importing countries cannot be assigned *a priori*. That means β_3 and β_4 are expected to have ambiguous signs [15]. The coefficient of distance, β_5 is expected to be negative because it is a measure of transport costs.

This paper introduces dummy variables (included in A_{ij}) to represent various regional trade agreements and English language. The dummy variables take the value one for membership of trade agreements or where English is the official language, and zero otherwise. The introduction of dummy variables modifies Equation (1) as:

$$\ln X_{ij} = \alpha_{ij} + \beta_1 \ln Y_{it} + \beta_2 \ln Y_{jt} + \beta_3 \ln POP_{it} + \beta_4 \ln POP_{jt} + \beta_5 \ln DIS_{ij} + \beta_6 EU + \beta_7 LANG + \beta_8 NAFTA + \beta_9 SADC + u_{ijt} \quad (2)$$

where α_{ij} is the individual effects, *EU* is the dummy variable for membership of the European Union, *LANG* is for countries with a common language (in this case English), *NAFTA* is the dummy variable for membership of North America Free Trade Agreement, and *SADC* is the dummy variable for membership of the Southern African Development Community. Membership of regional trade groupings can cause a rise in trade [14; 5; 10]. Common language may also be expected to promote trade. Their coefficients are expected to have positive signs.

III. ESTIMATION METHODOLOGY

Panel data involves different models that can be estimated. These are pooled, fixed effects and random effects. Since the regressions include individual effects, it is important to decide whether they are random or fixed. When estimating the trade flows between a randomly drawn sample of trading partners from a large population a random effects is more appropriate, while fixed effects model is more appropriate when estimating the flows of trade between an ex ante predetermined selection of countries [7; 12]. This paper analyses the trade between South Africa and 68 main trading partners, and therefore fixed effects will be a better model than the random effects model. The 68 main trading partners were selected based on the trade statistics of wood and articles of wood, wood charcoal for the period 1997 to 2004. The Hausman test statistic is applied to check further whether the fixed effects model is better than the random effects model. If the null hypothesis of no correlation between the individual or fixed effects and regressors is rejected, then fixed effects model is better than the random effects model.

Fixed effects model has a problem in the sense that variables that do not change over time cannot be estimated directly because inherent transformation wipes out such variables. To solve this problem, these variables can be estimated in a second step by estimating another regression with the individual effects as the dependent variable and distance and dummy variables as independent variables. This is specified as follows:

$$IE_{ij} = \eta_0 + \eta_1 DIS_{ij} + \eta_2 LANG + \eta_3 EU + \eta_4 NAFTA + \eta_5 SADC + \mu_{ij} \quad (3)$$

where IE_{ij} is individual effects, and other variables are as defined before.

IV. UNIVARIATE CHARACTERISTICS OF VARIABLES

The study covers the period 1997 to 2008 using annual data. Sixty eight main trading partners in the wood and articles of wood, wood charcoal (H44) sector were included in the estimation. The data for exports were obtained from Trade and Industrial Policy Strategies (TIPS) website: http://www.tips.org.za/node/636. Data for populations are sourced from the World Bank' World Development Indicators. The data on distance were obtained from http://www.timeandate.com, and they are computed as distance in kilometers between capital cities. The English Language dummy variable was sourced from [20].

Before the estimation of Equation (2) the paper analysed the univariate characteristics of the variables which entails panel unit root tests. This is the first step in determining a potentially cointegrated relationship between the variables. If all variables are stationary, then the traditional estimation can be used to estimate the relationship between variables. The detailed data source and description are provided in the Appendix. If they contain a unit root or are nonstationary, a cointegration test should be performed. There are three main different types of panel unit root tests. The first test is that of [11] and the second is [8]. These tests assume that the autoregressive parameters are common across cross sections. Levin, Lin and Chu (LLC) uses the null hypothesis of a unit root while Hadri uses the null of no unit root. The third panel unit root test allows the autoregressive parameters to vary across cross sections as well as for individual unit root processes. The test was developed by [9] and is referred to as IPS. It combines individual countries' unit root tests in order to come up with the result which is specific to the panel. According to [21], IPS has more power than the single equation Augmented Dickey Fuller (ADF) by averaging N independent ADF regressions. The specifications of the ADF tests can include an intercept but no trend or can include an intercept and a time trend. Under the IPS, the null hypothesis is that all series contain a unit root and the alternative hypothesis is that at least one series in the panel contain a unit root. IPS is a one-tailed or lower-tailed test and is based on N(0,1) distribution. This study applies the IPS and LLC tests and the results are presented in Table 1.

TABLE 1. PANEL UNIT ROOT TEST

	LLC	IPS
Export	-50.95 (0.00)***	-10.86(0.00)***
Importer's GDP	-17.70 (0.00)***	-6.29 (0.00)***
South Africa's GDP	-3.00 (0.00)***	10.98 (1.00)
Importer's population	-20.08 (0.00)***	-7.01 (0.00)***
South Africa's population	-6.89 (0.00)***	-2.21 (0.01)***

Notes: ***/**/* denotes rejection of the at 1%/5%/10% level. Probabilities are in parenthesis.

Table 1 shows that the LLC test reject the null of unit root for all variables. The IPS test rejects the null of unit roots for all variables, except South Africa's GDP. This paper uses rejection of unit root by at least one test in order to assume that the variable is stationary. The results of Table 1 indicate that all variables are stationary and this implies that cointegration test is not required and Equation (2) can be estimated using the ordinary least square method.

V. ESTIMATION RESULTS

Table 2 presents the results for the pooled, fixed and random effects models. The pooled panel data model results are in the second column of Table 2. The pooled model has problems because it does not allow for heterogeneity of countries and country specific effects are not estimated. It assumes that all countries in the model are homogenous.

The results of the fixed effects model are presented in column 3. The fixed effects model estimates country specific effects and introduces heterogeneity. To check the poolability of the data, the F-test statistic is performed. The pooled model is restricted and assumes a single intercept and same parameters over time and across countries. The unrestricted model (fixed effects or random) allows the intercept and other parameters to differ across countries. The results in Table 2 show that the null hypothesis of equality of the individual effects or homogeneity for all countries is rejected. This means that a model with individual country effects is better than the pooled model.

The random effects model results are in Column 4. This model acknowledges heterogeneity of countries. It is different from the fixed effects because it assumes that the effects are generated by a specific distribution. It also assumes differences in the cross-section or countries but does not model each effect separately. This prevents the loss of degrees of freedom which happens with the fixed effect. The null of no countries heterogeneity is again rejected in favour of random effects specification.

To test the null hypothesis that the regressors and individual effects are not correlated and discriminate between fixed effects model and random effects model, the Hausman test specification is used. If the null hypothesis is accepted the random effects model is a better model, but if it is rejected the fixed effects model will be preferred. The results in Table 2 show that the Hausman specification test rejects the null hypothesis and this means that country specific effects are correlated with regressors. This suggests that the fixed effects model is preferred.

TABLE 2. ESTIMATION RESULTS

Variables	Pooled model	Fixed effects model	Random effects model
Constant	-65.48 (-2.49)**	-8.95 (-0.47)	-37.94 (-1.94)*
Importer's GDP	0.66 (8.35)***	2.12 (7.49) ***	1.24 (7.12)***
South Africa's GDP	-0.66 (-1.67)*	-1.24 (-4.39)***	-0.90 (-3.35)***
Importer's population	-0.19 (-2.81)***	-7.48 (-5.32)***	-0.60 (-3.46)***
South Africa's population	4.94 (2.70)***	7.14 (4.02)	3.81 (3.07)***

		***	
Distance in kilometres	-0.56 (-2.10)**		-1.62 (-2.31)**
EU dummy	-0.401 (-1.59)		-1.39 (-2.08)**
SADC dummy	1.69 (4.19)***		1.20 (1.08)
NAFTA dummy	-1.95 (-4.34)***		-2.68 (-2.15)**
English language dummy	0.67 (3.702)***		0.63 (1.25)
Adjusted R-squared	0.18	0.68	0.59
F-test		17.30 (***)	
LM test			1320.99 (***)
Hausman test		63.21 (***)	

Notes: ***/**/* significant at 1%/5%/10% level
The t-statistics are in parentheses

The results of the fixed effects model as shown in Table 2 indicate that an increase in the importer's GDP causes an increase in the exports of South Africa's wood products and this is in line with the theoretical expectations. The coefficient of South Africa's GDP has a negative and significant sign and this is not consistent with the theory. This negative coefficient can be attributed to the fact that the construction sector experienced high growth rates in recent years, and wood products are used mainly in the construction sector. An increase or expansion in the South African construction sector can cause traders to reduce their exports and sell more of their wood products to the local market.

South African population has a significant and positive coefficient on the exports of wood products. This means that South Africa exports more when its population grows because of economies of scale. The importer's population has a negative and statistically significant effect on the exports of wood products. An increase in the importer's population implies that the domestic market (importers market) is large and there is higher degree of self-sufficiency and no need to trade in wood products. The results are as expected by the theory. They are also comparable to those estimated among others, by [6] and [18].

Country specific effects estimates are not presented in here because of space limitation, but obtainable from the authors on request. The country or cross-section specific effects show the effect of factors that are unique to each country but not included in the estimation of the model. They show that trade in wood products between South Africa and its trading partners differ from country to country and each country is unique. The results shows that there are unique features in some countries that promotes trade in South Africa's exports of wood products to Angola, Brazil, China, Democratic Republic of the Congo, Ethiopia, France, Germany, Ghana, India, Indonesia, Iran, Italy, Ivory Coast, Japan, Kenya, South Korea, Madagascar, Malawi, Malaysia, Mali, Mexico, Mozambique, Nigeria, Pakistan, Philippines, Poland, Russia, Spain, Sri Lanka, Tanzania, Thailand, Turkey, Uganda, USA, Vietnam, Zambia and Zimbabwe (countries with positive fixed effects). The results also show that there are unobservable country characteristics that discourage South Africa's exports of wood products to Australia, Belgium, Benin, Bulgaria, Canada, Congo-Brazzaville, Cyprus, Denmark, Gabon, Greece, Guinea, Hong Kong, Ireland, Israel, Italy, Kuwait, Maldives, Mauritius, Mexico, Netherlands, New Zealand, Norway, Portugal, Qatar, Saudi Arabia, Senegal, Seychelles, Singapore, Spain, Sweden, Switzerland, United Arab Emirates, and United Kingdom (countries with negative fixed effects). This suggests that an analysis of factors which discourage the exports of South Africa's wood products to countries with negative fixed effects is important for policy makers. This will help to identify constraints in wood trade and promote exports.

The second stage regression includes some factors which may explain the fixed effects. Table 3 presents the results of the second stage regression results. Table 3 shows that distance has a negative and insignificant effect on wood export. Membership of the EU and NAFTA is associated with a decrease in wood export, while SADC membership is associated with increase in export. Countries where English is the official language are associated with an increase in South Africa exports of wood products.

TABLE 3. SECOND STAGE REGRESSION: FIXED EFFECTS REGRESSED ON DUMMIES

Independent Variables	**Coefficient (t-statistics)**
Constant	1.203 (1.903)*
Distance	-0.056 (-0.779)
English Language	0.275 (12.275)***
EU	-4.283 (-68.512)***
SADC	4.014 (27.854)***
NAFTA	-3.274 (-32.021)***
Adjusted R-squared	0.984

***/**/* significant at 1%/5%/10% level

VI. TRADE POTENTIAL

The estimated fixed effects of Equation (2) is simulated to determine the within potential exports of wood products. More comparable simulation results could have been shown, but this is not done because of space limitation. The estimated exports are compared to actual exports in order to see if there is unexploited trade potential. The results are presented in Figure 1. The results shows that among others Canada, Comoros, Germany, Greece, Israel, Italy, Mauritius, New Zealand, Portugal, Russia, Tanzania and USA have unexploited trade potential at least from the year 2004 to 2008. For these countries, potential exports exceed actual exports. It is important to promote exports to these countries in order to exploit unexploited trade potential. However, a further analysis of each country is important in order to determine and identify possible factors that may inhibit export potential.

VII. CONCLUSION

This study estimated the determinants of South Africa's exports of wood products for the period 1997 to 2004 using a gravity model approach and analyse if there is unexploited trade potential in this sector. The estimation was done for 68 main trading partners in the wood product export industry. The paper found that importer's GDP and South Africa's population has a positive effect on exports of wood products, while South Africa's GDP has a negative impact on the exports of wood products. The negative effect of South Africa's GDP on exports of wood products can be explained by the high current growth of the construction sector in recent years. The importer's population has a negative impact on the exports of wood products, suggesting the trading partners become self sufficient as their populations grow.

Distance has a negative and insignificant effect on the exports of wood products. Membership of NAFTA and EU is associated with a decrease in exports while that of SADC is associated with an increase in exports of wood products. This indicates that not all regional trade arrangements cause an increase in the exports of wood products. South Africa exports more to countries where the official language is English, which suggests that sharing the same language promotes exports of wood products.

The estimated gravity equation was solved to determine if there are potential exports. Determining the potential exports is important especially when the market is not certain. The analysis found that among others, Canada, Comoros, Germany, Greece, Italy, Ireland, Mauritius, New Zealand, Portugal, Russia, Tanzania and USA have unexploited trade potential at least from the year 2004 to 2008. These results can serve as a guide to policymakers to ensure that the wood products export potential is exploited in order to accelerate growth. This can contribute to reducing unemployment and halving poverty by the year 2014.

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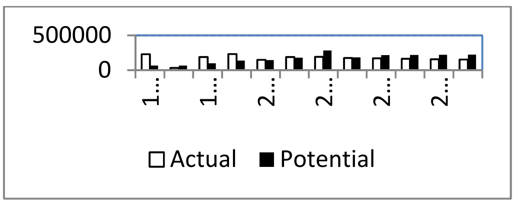
Canada



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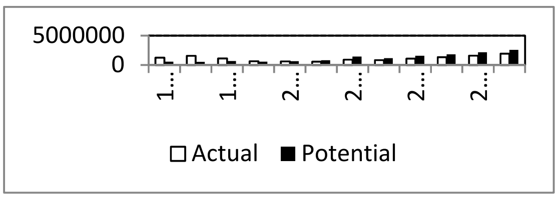

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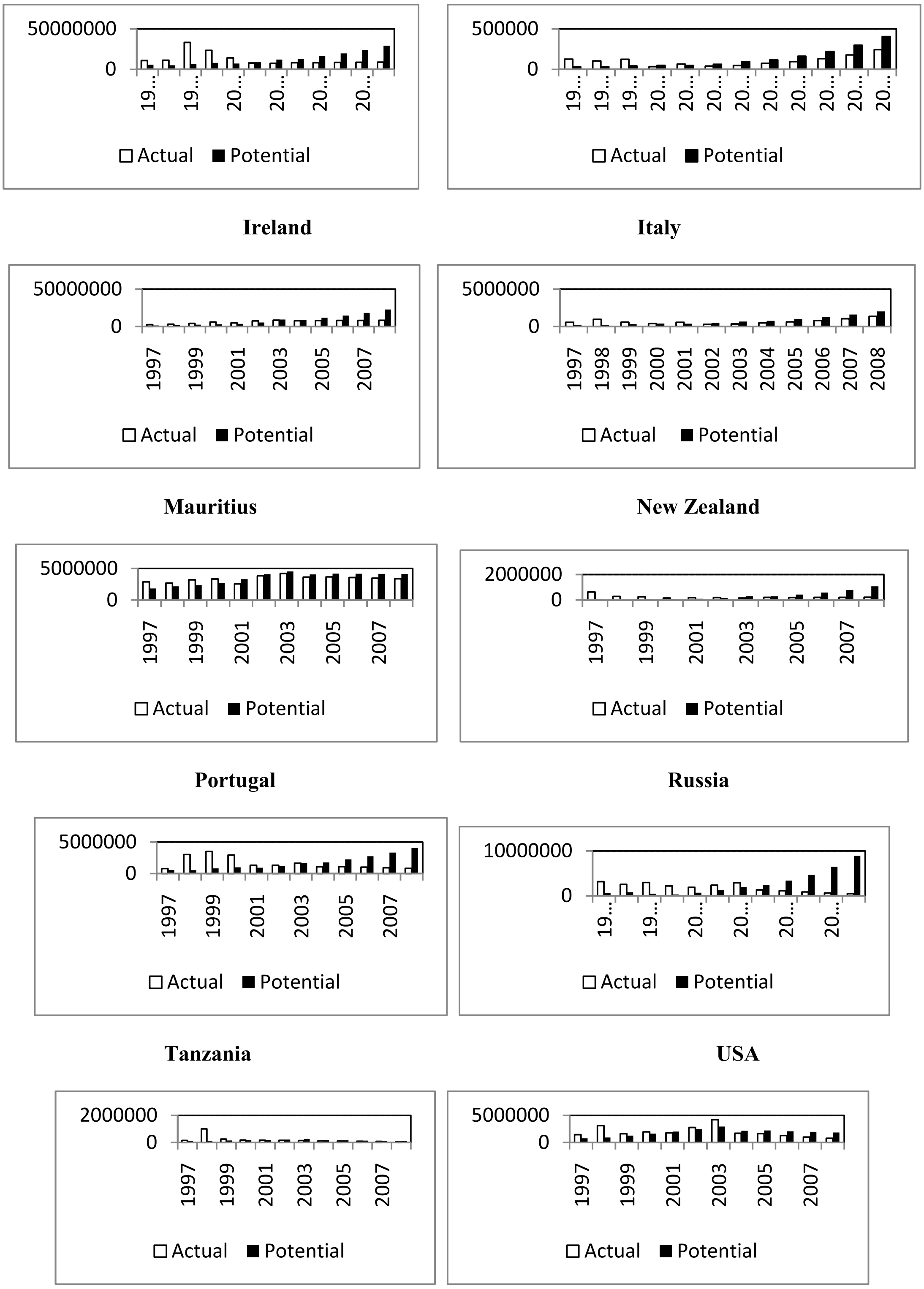

Figure 1. Actual and potential exports of wood products (in USA dollars).